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AN ELECTRICALLY OPERATED BOILER ROOM SCALE.—[See page 405.]

The Vitamines*

The Recognition of Essential Constituents of the Diet Hitherto Unclassified—Deficiency Diseases

By Percy G. Stiles

If a physiologist is asked what are the requisites of a normal diet he will probably reply somewhat as follows: First, it must represent an adequate quantity of available potential energy, not less than 2,000 calories for the average human adult. Second, it must contain protein (nitrogenous) food sufficient to compensate for the unavoidable daily loss of similar material from the body. Third, it must be palatable and digestible, making due allowance for personal idiosyncrasy. He will very probably content himself with these three postulates.

If the inquiry is pressed, the man of science may recollect that another necessary condition of successful nutrition is a proper supply of the inorganic or mineral elements in sufficiently varied assortment. The tissues cannot be developed or maintained without chlorides, phosphates and other saline contributions. The need for substances of this class is more urgent during the period of growth than later, but it always continues to exist. A similar statement may be made with reference to the protein of the ration; this, too, must be furnished in relative abundance and varied form during the growth of the subject and may be reduced when full stature has been reached. Mendel has shown that kind as well as quantity must be considered when protein is chosen for experimental nutrition of an animal. Proteins from certain sources suffice for maintenance only and not to minister to growth.

With the accumulation of physiological data during the past few years it has become increasingly apparent that there may be criteria for the adequacy of a diet not included in the list just given. There are now known to be organic compounds other than proteins, small quantities of which are absolutely essential to normal growth and even to continued health in the adult condition. The name of Vitamines has been proposed for all such substances. The word is well chosen in view of its root-meaning; an amine is a nitrogenous compound of a certain type and a vitamine is obviously such a compound with the added distinction of being necessary to life. Casimir Funk of London has been one of the foremost contributors to the development of this conception, and a valuable summary of his own work and his judgment of the work of others may be found in the *Ergebnisse der Physiologie*, Vol. xiii, pp. 124-205. (Wiesbaden, 1913.) This article is the chief source of the present abstract.

A class of serious disorders has long been known in which failure of nutrition could be named as the cardinal fact in the case, and in which it has somewhat vaguely been assumed that the diet must be at fault. The most familiar disturbance of this class, at least, to the general reader, has probably been scurvy. The chronicles of exploring expeditions in polar regions have contained many harrowing accounts of the ravages of this disease. It has usually been associated with the consumption of a monotonous ration, deficient in fresh vegetables and often containing a great deal of salted or canned food. Certain supplementary articles of diet, such as onions, limes and lemons, have been credited with some power to ward off or at least to mitigate the trouble, and they have been spoken of as antiscorbutics.

The victims of scurvy suffer from severe prostration, loosening of the teeth, intense soreness of the gums, friability of the bones and a tendency to hemorrhage, partly due to a loss of the coagulating property of the blood. Those who have read the classic journals of Doctor Kane will recall the distressing situation on board his ship at the end of the Arctic Winter and the commander's device to cheer his helpless men in the forecastle by setting up a mirror to bring into their midst the first sunbeam from the southern horizon. Scurvy has become less common with better supplies of food available for such parties, but it has been noted within a very few years.

Another disorder which has lately attracted much attention is beri-beri. It has its recognized center in the East, particularly in Japan, China, Indo-China and the Philippines. Its occurrence in Newfoundland has recently been reported. Those who suffer from beri-beri are usually the very poor, and, in the Orient, at least, they are people who live chiefly upon rice. In Japan the disease has been nearly eliminated from the army and navy by providing more liberal and varied rations. The symptoms are complex, but they are in general such as can be referred to the impairment of the nerves, which is known to be the most prominent physical change. There is a period of declining weight and strength, and this is followed by the development of a "multiple neuritis," with partial paralysis in both the motor and the sensory realms.

Various theories have been held with regard to beri-beri. It has been believed to be an infectious disease because it so often affects a large number of people who are closely associated, as in a prison, a ship or a laborers' camp. The fact was formerly overlooked that such companies share the same diet and that their trouble may well be due to that source. This is now accepted as proved. But when the decision is reached that something must be wrong with the food there are still two possible views to be considered. Is the diet positively poisonous or is it merely insufficient? This question has been asked both with reference to scurvy and to beri-beri. It is not easy to answer it in such a way as to meet all objections. Nevertheless, the tendency is toward the conclusion that it is the inadequacy rather than the toxic nature of the food which is to be held responsible in these and perhaps in other cases.

It is proposed to call such failures of nutrition "deficiency diseases." It is assumed that the lack is of one or more of the specific substances already termed vitamines. The evidence in support of such a conception is especially convincing in the case of beri-beri. As long ago as 1897 it was discovered that rice which has been "polished"—that is, deprived of its pericarp or immediate husk—has a tendency to induce beri-beri, and that the inclusion of the pericarp makes it entirely wholesome. It has been possible to confirm this in a striking manner by experiments on birds. If a fowl or a pigeon is restricted to polished rice as a diet it soon refuses to eat. If forced feeding is then resorted to it soon becomes pitiably weak and cannot long survive. The partial feeding is thus as surely destructive as absolute starvation. Post-mortem study of such birds shows marked degeneration of the nerves. The service of the pericarp may be conceived of in either of two ways. The polished rice may contain an active poison for which the husk provides a natural antidote. The alternative is that the pericarp furnishes a necessary constituent of the nerve tissue, a vitamine, for want of which the nerve-fibers deteriorate. How hard it is to choose between these two views has already been suggested.

Funk has been successful in his patient endeavor to isolate the vitamine, the lack of which causes beri-beri. He has obtained from the pericarp of rice a number of fractions, only one of which has the remedial property. This appears to be a definite organic body to which a formula can be assigned. It contains nitrogen, but not phosphorus, an element which earlier workers had believed to be concerned. The vitamine can be separated from other foods than rice. Various animal tissues yield it and so do certain vegetables. Any kind of food which contains the vitamine may be used to supplement a ration of polished rice with the result that it becomes sufficient for the maintenance of the animal. Yolk of egg and yeast are said to have the curative power in the highest degree.

It is interesting to follow Funk's conjectures as to the systemic effects of the withholding of the invaluable vitamine. We know that in starvation the organs which cannot be spared are sustained at the expense of others. The heart and the nervous system have been found to keep their full weight to the last, while tissues which are less necessary to the continuance of life are greatly reduced. Even the bones are levied upon to the extent of one sixth of their mass. We may expect to see the same principle illustrated in the partial starvation which is at the root of any deficiency disease.

So in beri-beri it may be supposed that the vitamine which is absolutely essential to the normal nervous system is not at first confined to that part of the body. The feeding experiments have given evidence that it is present in the muscles though rather scantily. It is to be expected that in the event of failure of a supply direct from the diet the muscles will be made to surrender their store of the vitamine to replace that which has been destroyed in the nervous tissues. If we are to think that the vitamine is essential to the muscles as well as to the nerves, we shall anticipate that its withdrawal will result in a disintegration of the muscle protoplasm quite out of proportion to the small amount of vitamine yielded to the preferred creditor. So for a while there will be loss of weight and strength, but no marked nervous symptoms because the nerves are being kept in condition at the cost of a remorseless sacrifice of the other tissues. When the internal supply ceases to be sufficient, the acute nervous effects which have been spoken of above are at once developed.

It is the opinion of Funk that both beri-beri and scurvy are prevented by the liberal use of potatoes. Before this vegetable was introduced into Europe there were severe epidemics which are believed to have been outbreaks of scurvy. The suggestion that the potato should now be added to the food-supply of the Eastern countries in which beri-beri is prevalent seems to be a wise one. But the fact is to be emphasized that almost any diet is free from objection if it is reasonably varied. It is where poverty or some other compulsion is operative that nutritional disasters are likely.

The condition of the body in scurvy is quite different from that in beri-beri, and the missing compounds are probably somewhat unlike. Some articles of diet may protect against both; some may be specific for only one. Allied with scurvy are the disorders called ship beri-beri, infantile scurvy (Barlow's disease) and the experimental scurvies which can be produced in animals by limiting the intake to a few foods. Still other pathological states may be found to have a more or less similar basis. An attempt has been made to justify the claim that pellagra is a deficiency disease, but this is strongly contested. Abnormalities of early development such as rachitis (rickets) and, perhaps, later perversions of growth such as cancer may be connected with the lack of certain chemical constituents in the income of the body. At this point it may be in order to say that the diet itself may conceivably be ideal and yet there may be a failure to utilize the vitamines offered either because of a failure to absorb them or because of their premature decomposition in the alimentary tract.

A few years ago Crichton-Browne, an English authority, in passing an unfavorable judgment upon the dietetic standards of Chittenden and others, called attention to the fact that the diet approved by them seemed to correspond closely with that of the very poor. The comparison was based upon fuel value and protein content. It is now possible to modify the statement that the two are precisely equivalent. The low diet of the New Haven school is an inclusive one, while that of the poor is of limited variety. A supply of the requisite minor bodies—vitamines, if we adopt the term—is much more surely to be relied on in the first case.

Bunge, the Austrian physiologist, pointed out in 1901 that sugar is an unnatural food, in that it has been refined to the exclusion of all compounds but saccharose. Foods which are not deliberately prepared by industrial or domestic processes are always mixtures, however much one constituent may predominate. The teaching of Sylvester Graham in the first half of the nineteenth century that the foods offered by nature should not be separated into their ingredients, but taken in their entirety is frequently re-echoed in our own day. In the light of studies like those of Funk, it is apparent that there is a certain foundation for the idea that foods may be "denatured" either by discarding valuable fractions or by modes of preparation which destroy essential compounds. The fear that disturbances of nutrition from such causes threaten the American people as a whole may be dismissed, but it is interesting to have a new insight into a matter which under certain conditions becomes of pressing importance.

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Catalysis in Organic Chemistry

By the invitation of the University of London, Prof. Paul Sabatier, of Toulouse delivered two lectures on catalysis at King's College on May 14th and 15th. The two lectures were delivered in French, and were illustrated by a series of experiments in which the catalytic action of nickel, of copper, of alumina, of zinc oxide, of titanium dioxide and of thoria was shown in actual operation. Prof. Sabatier is a whole-hearted advocate of the chemical as opposed to the physical theory of catalysis. He holds that in all cases intermediate compounds are formed, e. g., PtO in catalytic oxidations in presence of platinum and NiH_2 in catalytic reductions in presence of finely divided nickel. He finds ample support for his views in the totally different effects that are often produced by catalysts which are almost identical in their physical properties. Thus formic acid vapor is decomposed wholly into hydrogen and carbon dioxide when passed over zinc oxide, but into water and carbonic oxide when passed over titanium dioxide:

$$H_2+CO_2 \xleftarrow{ZnO} H.CO.OH \xrightarrow{TiO_2} H_2O+CO.$$

Ethyl alcohol in like manner may be converted into

aldehyde and hydrogen by finely divided copper, or into ethylene and water by alumina:

$$H_2+CH_3.CHO \xleftarrow{Cu} CH_3.CH_2OH \xrightarrow{Al_2O_3} H_2O+C_2H_4.$$

Different catalysts also differ very widely in their efficiency in promoting any given chemical change. Alumina can be used very effectively to convert alcohol into ethylene and water, but it becomes clogged with tarry matter which cannot be burned off without destroying the catalytic properties of the oxide; thoria, on the other hand, becomes contaminated less readily, and can be purified by ignition without losing its activity. Again, thoria is a very useful catalyst for converting acids into ketones, e. g.:

$$2CH_3.CO.OH \rightarrow CH_3.CO.CH_3+CO_2+H_2O;$$

but titanium dioxide is so efficient and acts at so low a temperature that it can also be used to prepare aldehydes from mixtures of fatty acids with formic acid, and esters from acids (such as formic acid) or alcohols (such as the secondary and tertiary alcohols), which lose water so easily that it is difficult to esterify them without decomposition. On the other hand, the best catalyst for preparing ketones and other derivatives from benzoic acid is ordinary chalk. A very important catalyst is manganous oxide, which can be prepared easily and cheaply from manganous carbonate, and can be used in almost every case for the preparation of ketones in place of thoria or titanium dioxide.

Prof. Sabatier laid stress on the reversibility of catalytic actions. Thus, nickel will promote dehydrogenation as well as hydrogenation, and very small differences of conditions are required to cause the reversal of actions such as those which are shown by the equations:

$$C_2H_4O+H_2 \rightleftarrows C_2H_6O$$

$$C_6H_6+3H_2 \rightleftarrows C_6H_{12}.$$

An interesting account was given of the way in which acetylene in contact with nickel at different temperatures and in presence of varying proportions of hydrogen gives rise to complex products which are in every respect identical with natural petroleums. By varying the conditions the product can be made to resemble the four chief natural types as derived from North America, from the Caucasus, from Galicia and from Roumania. These observations suggest a theory of the origin of petroleum that has a far higher claim to acceptance than most of those that have been put forward hitherto.

Prof. Sabatier touched only lightly on the technical applications of his new methods. The vast industry which has sprung up within the last two or three years, in this country, on the Continent and in America, was illustrated by two small samples of oils that had been hardened by the action of hydrogen in presence of finely divided nickel; reference was also made to the fact that in the process of hardening the disagreeable taste and smell of the fish oils are completely removed.

It is not too much to say that Prof. Sabatier has introduced a new era in organic chemistry. The advantages of catalytic methods are obvious: the catalyst will last for an indefinite period unless its activity is destroyed by overheating, which is generally fatal, or by "poisonous" impurities, such as sulphur or the halogens, which quickly arrest the catalytic hydrogenation of organic compounds by nickel. The only materials required are those which are essential constituents of the products, and in almost every case the first effect of the successful introduction of catalytic methods is to bring about a great reduction in the cost of production. The rapid extension of these methods is therefore a matter of great scientific and technical importance.—*Nature.*

Eggs By Parcel Post

Better Prices for the Producer and Fresher Goods for the Consumer.

THE *Farmer's Bulletin*, No. 594, of the Department of Agriculture, prepared by L. B. Flohr and issued in June, 1914, gives interesting details respecting the best methods of selection and packing eggs for mail transportation. That eggs can be marketed successfully by parcel post, and that this method frequently secures a better price for the producer and a fresher article for the consumer, has now been demonstrated to the satisfaction of the experts in the U. S. Department of Agriculture. The Department conducted tests that covered a period of five months. At the end of that period it came to the conclusion that the parcel post was of particular value to the man whose flock was too small or who lives too far from express service to permit him to ship his eggs in the regular commercial case which holds 30 dozen eggs.

In the course of these experiments the Department shipped 9,131 eggs in 466 lots. Of these 327, or slightly less than 3.6 per cent, were broken, but only 209, or slightly less than 2.3 per cent, were absolutely wasted. The others, though broken, could still be used. The percentage of breakage, moreover, will be greatly reduced, it is said, when the employees of the post office become more accustomed to handling such fragile matter.

That the eggs should be properly packed is, of course, essential. This implies time, care and some expense, and is one reason why no attempt should be made to market by parcel post any but the finest quality of eggs, for they alone will bring remunerative prices. Moreover, if the customer who buys in small lots finds that any considerable proportion of his purchases is undesirable or even unattractive in appearance, he will not trouble to ask for deductions on that account; he will simply discontinue his orders. The producer, therefore, must see to it that all the eggs the post-man delivers are what he represents them to be.

This can only be done by candling them. Candling, "the process of testing eggs by passing light through them so as to reveal the condition of the contents," is omitted by many producers, who rely on care in collecting to eliminate all bad eggs. It is, however, impossible to avoid an occasional accident, and candling is therefore advisable, as an extra precaution. A simple outfit can be made out of a small hand lamp and an ordinary pasteboard box sufficiently large to be placed over the lamp, after the ends have been removed, without risk of fire. In order to supply air to the enclosed lamp, notches should be cut in the edge on which the box rests. A round hole is then cut in the box at the level of the lamp flame and the candling done by holding each egg against this hole while the rest of the room is in darkness. The light from the lamp reveals the contents of the egg, and those that show any defect can be rejected.

If possible, only infertile eggs should be sent to market. Fertile eggs deteriorate rapidly in warm weather and are the cause of much loss. A broody hen on the nest or accidental exposure to a high temperature may start incubation and cause the egg to spoil and injure the shipper's reputation. It is advisable, therefore, to retain the fertile eggs for home use or dispose of them in some other way than through the parcel post. This is also true of soiled eggs. Eggs should never be washed when intended for high-class trade, since the process removes a natural mucilaginous coating and opens the pores of the shell.

After this thorough elimination of the unfit, the eggs that remain should be carefully packed in a container of corrugated pasteboard, metal, wood, or other suitable material. The post office regulations require this container to be so wrapped that nothing can escape from the package, and each egg, in addition, to be wrapped separately in excelsior, cotton, or some such material. Any soft paper serves the purpose quite well. As for the container itself, there are many kinds on the market, and the Department of Agriculture investigators have not attempted to decide which is the best. Instead, they refer inquirers to the various State experiment stations, which have available information on this question.

In packing eggs it is well to sort them as far as is practical, according to size and color, and to keep for home use those which are irregular in shape, unusually long or thin-shelled. Containers that have been badly stained by broken eggs should be replaced by new ones and the package wrapped as neatly as possible. In short, every effort should be made to deliver as attractive a package as possible into the hands of the customers. The extra expense will be little and the returns in increased trade great.

The larger the shipments that the producer can arrange to make, the cheaper can he afford to sell his eggs. Within the first and second zones of the parcel post service, a package costs 5 cents for the first pound, and only 1 cent for each additional pound. Ordinarily, eggs weigh about 1½ pounds a dozen, which with the additional weight of the wrapping and container, would make a package of a dozen eggs weigh between 2 and 3 pounds. The postage on this would be 7 cents. If another dozen eggs were included in the package the postage would not be more than 9 cents, or 4½ instead of 7 cents a dozen eggs.

To the value of the eggs and cost of postage must be added the cost of the container and the wrapping. For two dozen eggs this may be estimated at 8 cents. With postage at 9 cents it would, therefore, cost 17 cents to market two dozen eggs, or 8½ cents a dozen. By shipping in 10-dozen lots, it is estimated that the marketing cost can be reduced to 4.7 cents a dozen.

Where the container can be used more than once, this cost can, of course, be somewhat reduced. Large-sized containers will stand from two to four trips, smaller ones three to five, so that it will pay the producer to induce his customer to return the containers periodically. The postage required for this is, of course, deducted from the bill for the next shipment.

Although it is obviously advantageous both to the producer and consumer that the eggs be shipped in large quantities, and consequently economically, it must be remembered in taking orders that the supply of eggs undergoes the greatest fluctuations. In times of scarcity it is not good policy for the producer to send all his output to one customer, neglecting his other friends, nor in times of plenty can be expect to dispose of his entire stock to his regular customers. These points must be given due consideration and the quantities that are to be supplied at each season of the year carefully stated in the contract. The price, too, varies with the supply. One good method of determining this is to take as a basis the wholesale price of eggs on the open market and add to this a certain number of cents a dozen for the new-laid parcel post eggs. Care should be taken, however, to see that there is no possibility of any misunderstanding arising in regard to the basic price. To obviate this, the quotations published in a given newspaper or some other similar authority may be accepted.

Eggs are scarcest and highest in the Fall. Chickens should, therefore, be hatched early enough to begin laying at this season. Moreover, little difficulty will be experienced then in disposing of the entire output, and it will, in consequence, be unprofitable to divert any of the supply to home purposes. This difficulty can be overcome by preserving eggs in the Spring, when they are plentiful and cheap. A solution of water glass, which can be obtained at drug stores for 75 cents a gallon, should be used for this purpose, each quart being diluted with 10 quarts of water which has been boiled and cooled. The eggs should be packed in stone jars or crocks and the solution poured over them, or they may be carefully placed in the solution each day. Eggs kept in this way are perfectly good, but naturally they do not command the prices of those newly laid. The shells sometimes break in boiling, but this may be avoided by puncturing the end with a pin just before they are dropped into the water.

The only drawback to marketing eggs by parcel post appears to be the time and trouble involved in packing them. This is compensated for by the extra price that can always be obtained for products that are absolutely reliable. At bottom, therefore, the shipper's success depends upon the care with which he safeguards the reputation of his products. Satisfied customers will soon build up his business for him. Any post office will furnish complete information in regard to regulations and rates, and, as already stated, the several State experiment stations have information in regard to the various types of shipping boxes.

A summary of the results and experience as stated in the *Bulletin* is as follows:

(1) In the experiments conducted in this study 760 11/12 dozens, or 9,131 eggs, were sent through the mails in 466 shipments of from 1 to 10 dozens each. The total breakage was 327 eggs; of these, 118 were only cracked or slightly broken and were usable, and 209 (or 2.3 per cent) were broken beyond use. Ninety-one eggs were broken because the parcels containing them were handled contrary to postal rules and regulations. Subtracting these, the loss was only 1.3 per cent. This shows the possibility of shipping eggs by parcel post with small loss, and indicates that eggs may be so shipped with safety if existing postal regulations are observed.

(2) Care should be exercised in the production of eggs so that they will be of as good quality as possible to begin with. The hens should be provided with proper quarters and fed on clean, wholesome feed. The production of non-fertile eggs reduces the losses materially. After gathering, the eggs should be kept carefully in the coolest and best ventilated place available.

(3) Trials of many styles and makes of containers were made; quite a number proved satisfactory. The addresses of manufacturers of containers can be obtained from the agricultural experiment stations in the several States.

(4) In selecting eggs for shipping by mail, thin-shelled and unusually long or irregular-shaped eggs should not be used. Each egg should be wrapped in sufficient paper to hold it snugly in its own individual compartment in the container. The container should be properly closed and carefully wrapped with good, tough wrapping paper and strong twine. The address should be plainly written to insure prompt delivery on arrival. The postal regulations require the name and address of the sender on the parcel also.

(5) If attention is given to the necessary details, eggs can be shipped by parcel post to the advantage of the farmer. This method of marketing affords a means of increasing the fresh-egg business to the benefit of both the producer and the consumer, by marketing direct while the eggs are still in fresh condition.

(6) Farmers located out of reach of a satisfactory market or of the usual means of transportation can find in the parcel post a ready means of getting their eggs direct to a consuming market promptly and at prices that will justify the additional trouble involved in packing for mailing.

Modern Forms of Roentgen-Ray Tubes*

How the Problems of Construction and Operation Have Been Met

By Charles E. S. Phillips

In spite of many obstacles, medical technique in the application of Roentgen rays has made steady progress during recent years. But there still remain certain primary difficulties which are often a source of hindrance and confusion. The demand for a more trustworthy method of working than exists to-day is the natural outcome of wider radio-therapeutic experience, but what is required above all is an accurate means of measuring the output of the tube.

The solution of this problem clearly requires that we shall have at our disposal an apparatus capable of emitting a specific type of ray in definite quantity; and were it not for some experiments by Dr. Lilienfeld, and more recently Mr. Coolidge, of New York, there would be little prospect of actually realizing this result in practice. I shall refer to their work more in detail later.

Meanwhile, it is worth noticing that the modern X-ray tube, with all its imperfections, is a triumph of craftsmanship. It is the result of numberless costly and difficult experiments carried out by manufacturers and others to meet a demand which grows more exacting every year. The collection of historical X-ray tubes brought together some time ago by the Roentgen Society, and now on view in the Science Museum at South Kensington, contains the first bulb which embodied the chief features adopted universally up to the present time in the construction of X-ray tubes. That bulb was made by Prof. Herbert Jackson in 1896, and measured only three inches across. The diameter of those in use to-day is, however, usually twice or three times as great, the electrodes being heavy and the vacuum carefully adjusted.

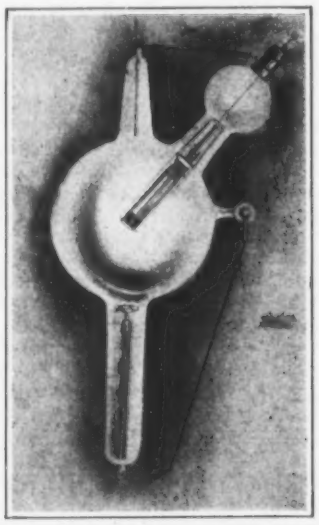


Fig. 2.—Heavy discharge X-ray tube.

The successful working of the apparatus depends so largely upon this last factor that decrease in pressure of the residual gas, invariably accompanying prolonged use, has to be compensated for. The devices employed for regulating the vacuum may be divided into three main classes, viz., those:

(1) In which a few disks of mica, a piece of carbon or asbestos, etc., fixed within the bulb, offer an alternative path for the discharge, so that gas is, when necessary, liberated by the heat generated, as the electric current follows the line of least resistance.

(2) In which a fine palladium tube stopped up at one end has a small tubular extension of platinum soldered to it for sealing into the X-ray bulb. A gas flame brought near so as to heat the palladium enables hydrogen to enter by osmosis, and so lower the vacuum. All the tubes used in the X-ray treatment cubicles at the London Hospital, for instance, have these "Osmo" regulators.

(3) In which air is allowed to enter through the pores of a piece of unglazed porcelain, which is usually sealed with mercury until by a pneumatic contrivance it is momentarily uncovered.

But none of these methods is free from objections. The regulation is generally too insensitive. The tube often outlives the supply of gas from the first sort, and the others are only trustworthy in skilled hands. The mica disk regulator is shown in the diagram (Fig. 1), which otherwise is self-explanatory.

* Reproduced from *Nature*.

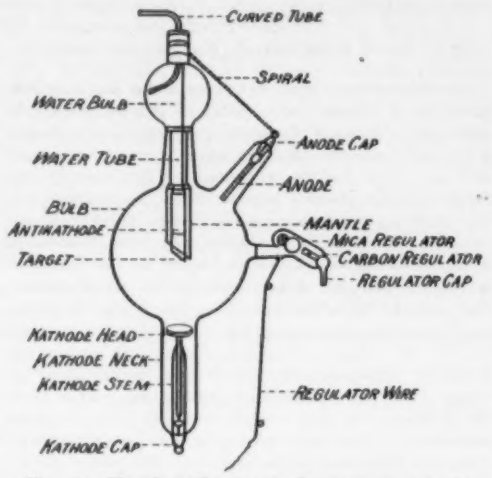


Fig. 1.—Showing the terms in common use to denote the different parts of the instrument.

Messrs. C. H. F. Muller describe some eighteen types of tubes of this character in their recently published catalogue, and give precise instructions for the adjustment and use of each kind. There are, in addition, five colored plates showing the appearance of X-ray bulbs in action, and a great amount of useful information besides. Fig. 2 (Muller) may be taken as representing a typical example of modern heavy discharge X-ray tube.

The cause of the disappearance of gas with prolonged use has given rise to much speculation. It has been suggested that the ions produced by the discharge are driven actually through the walls, and so escape; there is proof at least that the glass takes up a large part of the residual gas under these conditions, and that lead glass absorbs more than Jena.

Since the degree of vacuum controls the resistance of the tube, and this in turn determines the current that passes with a given potential difference between the electrodes, it is evident that the pressure of the residual gas is the chief factor which defines the type and quantity of rays to be obtained. Moreover, the kathode itself must carry a minute trace of gas to facilitate the transfer of electricity from the metal to the surrounding space. Further, the great heat often generated at the antikathode raises the temperature of the walls to such an extent that gas is set free there, and the balance of working conditions upset. A new tube, in fact, generally requires "maturing" until its vacuum when at work will keep practically constant, and yet be neither too high nor too low. This calls for much care and patience on the part of the operator. A bulb may in this way be coaxed to carry 5 milliamperes for hours at a stretch, and be of great service in "treatment." In most cases, however, the current does not exceed 2 milliamperes for that purpose. But in radiographic work the usual practice is to employ a heavy current—20 milliamperes—for a few seconds or even a fraction of a second. The length of exposure is, of course, determined by a number of considerations, but with such a large current it cannot exceed a few seconds on account of the enormous heat generated at the antikathode by the impact of electrons.

The same difficulty is met with in the treatment tubes, quite apart from the disengagement of gas, for a longer exposure has to be given now than would be necessary if more current could be carried with regularity and safety.

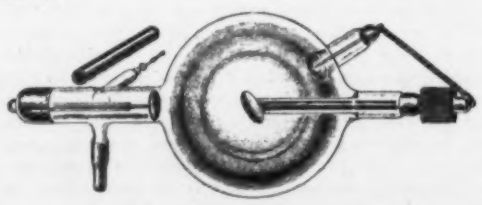


Fig. 3.—Heavy discharge radiator tube.

Under existing conditions the antikathode stem is usually made hollow, so as to enable water or air to flow in and carry off the heat, or an actual radiator may be fitted, as shown in Fig. 3 (Cossor). The osmosis regulator is also represented in the same illustration. Otherwise, even the hardest substance used as target would melt or become pitted by the impinging electrons. As an example of what occurs, the photomicrograph (Fig. 4, for which I am indebted to Dr. Rodman) of a plate of platinoid-nickel which has served as target may be of interest. In all cases, except for very light work, the antikathode is made of stout copper, faced with platinum-iridium or pure iridium, tantalum, etc., at the place where the kathode rays impinge upon it. The uncertain variation of vacuum, together with the development of excessive heat at the antikathode, constitute the most serious objections to the present system of working. The first difficulty especially hinders progress toward the attainment of an accurate method of measuring or describing the radiation dealt with, for it may change from day to day, or even during an exposure. But there are, in addition, many minor ailments which develop with the age of the tube. Thus a deposit comes gradually upon the inner surface of the walls. It is mainly metallic, and occludes gas; but it also provides electrified areas which disturb the normal streams of electrons. Occasionally, too, patches of bright fluorescence appear on the glass, due to specks of foreign matter sticking to the kathode. The direction of the discharge will sometimes reverse in the tube from no apparent cause. Indeed, the behavior of a bulb is so erratic at times that a superstitious person might be excused for regarding it with distrust.

However, with care and experience, and in spite of many disadvantages, splendid work is being done with this super-sensitive apparatus. But it is none the less necessary to make every effort toward placing X-ray therapeutics upon an accurate quantitative basis, and to simplify the technique. With existing appliances the prospect of so doing is remote, indeed.

But we are on the eve of great improvements! Dr.

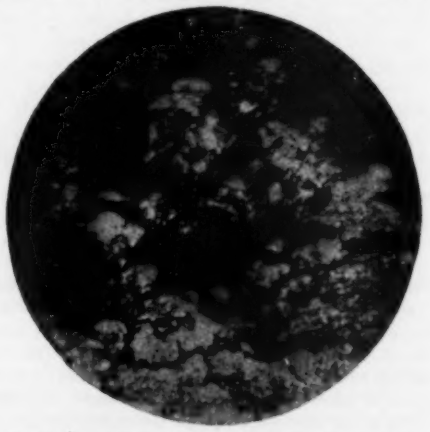


Fig. 4.—Photomicrograph of eroded target.

Lilienfeld of Leipzig has already constructed a Roentgen tube which is so highly exhausted that the residual gas plays no part in the working of the apparatus. The first description of this new departure was given in the *Fortschritte auf dem Gebiete der Röntgenstrahlen* for June, 1913, and more recently a further account has appeared in a later issue (Band xviii, p. 256).[1]

Dr. Lilienfeld creates an electric field in the neighborhood of the antikathode between an aluminium tube and a white-hot wire. The working potential difference is then applied to the main electrodes and a discharge immediately passes. Since the current taken by the tube depends upon the temperature of the so-called priming device, the operation is under control.

But Mr. Coolidge[2] has simplified this design still further by placing a small spiral of tungsten at the center of the kathode; heating this by an independent current he obtains a supply of electrons which are repelled and driven against the target with such speed as to produce copious X-rays where they strike. Thus, given a powerful induction coil and noting that the bulb is so well exhausted that 100,000 volts at its electrodes produce no discharge, the spiral is heated and the current that then passes is simply a function of the temperature. Variation of the potential difference would mean an alteration of the speed at which the electrons are driven against the target. The *quality* of the X-rays produced can therefore be varied, irrespective of their quantity.

[1] A good summary is published in the *Archives of the Roentgen Ray*, for February, p. 340.

[2] *Physical Review*, December, 1913.

This is not possible with any other type of X-ray tube. Its importance cannot be overrated. It places in the hands of X-ray operators an instrument of precision. Many questions are still outstanding; it is not even claimed yet that this apparatus is beyond the experimental stage. Meanwhile, however, it may be of interest to point out that the Coolidge tube has already given some remarkable results. The most successful bulb so far made measured 18 centimeters in diameter, and was blown from German glass; it carried a current of from 1.7 to 36 milliamperes with the spiral heated to a temperature varying between 2,010 degrees and 2,240 degrees absolute. It was run for fifty minutes continuously on one occasion with 25 milliamperes passing. There was, of course, great heat developed in the antikathode, but the regularity of the action seems to have been unaffected. No fluorescence appeared upon the glass of this bulb, and the starting and running voltages were identical. The tube is also its own "rectifier," and may be run off an alternating circuit without any additional device to suppress one phase.

The prospect of being able to speed up the electron so much that it may give rise to a radiation with a wavelength equal to, or even shorter than, that of the Gamma ray from radium, offers great therapeutic possibilities.[1]

It remains so far to improve the means of supplying electricity to the tube that a steady potential difference may be maintained at its electrodes. Then, since reversal seems impossible with the Coolidge system, it should be feasible to produce pencils of approximately *homogeneous* X-rays in definitely measurable *quantity* and of a *quality* expressed in terms of the coefficient of absorption in some agreed substance.

[1] This has quite recently been accomplished by Friedrich Dessauer of Frankfort a. M., as we recently reported. A more detailed account of Dessauer's work on the production of X-rays of very high penetrating power, resembling the Gamma rays of radium, will shortly appear in our columns.

The Reality of the Ether*

By Prof. L. Houllevigue

THE nature of the ether has long been the subject of discussion. Some physicists deny the reality of the ether, while others refuse to renounce their belief in a medium of propagation of luminous and electromagnetic waves. Recent experiments of Michelson and Sagnac give support to the belief in the reality of the ether.

Michelson remarks that the undulatory theory carries the corollary that the velocity of propagation of waves is not affected by motion of their source or of the mirror by which they are reflected. In the emission theory, on the contrary, the velocity of propagation is affected by motion, either of the source or of the mirror. If the reflection is like that of an elastic ball, it must increase the velocity by an amount equal to twice the component of the mirror's velocity in the direction of propagation, while, if the mirror acts as a secondary source of emission, the increase of velocity is equal to that component.

In order to decide between the two theories, Michelson devised the apparatus shown in Fig. 1. The monochromatic light of a source *S*, falling upon a lightly silvered mirror *A*, is divided into two beams *S, A, D, E, C, B, A, I,* and *S, A, B, C, E, D, A, I,* which meet again at *I* after traversing the same path in opposite directions. The beams are reflected by the mirrors *D* and *C*, which rotate about a common axis *O* at the rate of 1,800 revolutions per minute, and also by the fixed concave mirror *E*, about twenty feet distant from the rotating mirrors. Interference fringes are observed at *I* even when the mirrors *C* and *D* are at rest. When the mirrors rotate, the paths traversed by the two interfering beams are not necessarily equal, because the mirrors are displaced during the passage of the waves to *E* and back. According to the undulatory theory, therefore, the rotation of the mirrors should displace the fringes by an amount equal to 3.76 fringe-intervals. The observed displacement was 3.81 such intervals. If light were reflected like an elastic ball, it can be shown that the fringes would remain motionless.

In Sagnac's experiments the ether proves its reality

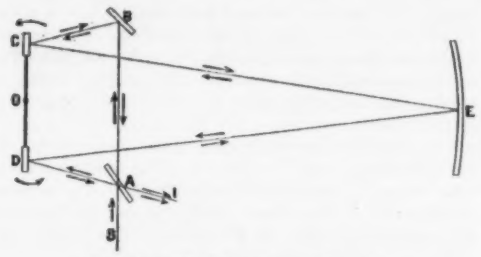


Fig. 1.—Michelson's experiment.

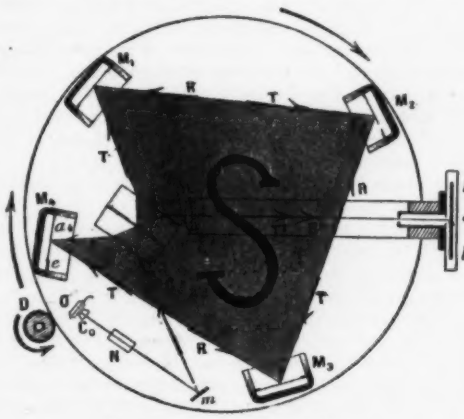


Fig. 2.—Sagnac's experiment.

by its resistance to rotary movement. The apparatus is a rotating interferometer (Fig. 2). A horizontal plate, which can be rotated in its own plane in either direction by means of a friction wheel *D*, carries a source of light *O*. A beam from this source is guided by appropriate devices to a thin stratum of air *j*, between two glass plates, where it is divided into two beams, *T* and *R*. These beams, reflected by the mirrors M_1, M_2, M_3, M_4, circulate in opposite directions around the shaded area *S* and, reuniting in T_2, R_2, form interference fringes on a fine-grained photographic plate *p p'* at the focus of the lens *L*. The whole of this apparatus rotates together as a connected and isolated system. Hence the principle of relative movement appears to demand that the position of the fringes on the photographic plate shall be entirely unaffected by the rotation. This conclusion, however, is at variance with the observed facts. If the apparatus is rotated, at first in one direction and then in the other, the photographs taken during the two rotations show a displacement of the fringes, and this displacement is exactly equal for the value calculated on the assumption that the ether, the medium of undulation, does not participate in the rotary movement of the material system. On this assumption the rotation produces a relative ether current, with respect to the rotating apparatus, and this relative ether current retards one of the interfering beams of light and accelerates the other.

The displacement of the fringes, which is produced by reversing the rotation, is about 0.03-inch, so that it is not only appreciable but easily measurable, and it is of the same sign and the same magnitude as the displacement calculated on the assumption of a motionless ether. Sagnac appears to have taken every conceivable precaution against error. If he has really done so, the result of his experiments is one of the most important contributions to optics that has been made since Fresnel's time, for it proves indisputably the existence of a wave-transmitting medium which is independent of material media.

* Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from *Revue Générale des Sciences.*

An Electrically Operated Boiler-Room Scale

OUR front page illustration shows an electrically operated boiler-room scale as utilized in the Post Street Station of the Puget Sound Traction, Light and Power Company. This electric suspension boiler-room scale was installed to secure a quick and accurate weight of all coal going into the seven automatic stokers.

The car on which the scale and hopper is suspended has an electric motor of 2 horse-power, 230 volts, direct current, series wound enclosed type operated by a reversible crane controller having five speeds forward and reverse for operating this weighing machine.

On this suspended boiler-room scale, the weighing operation is very simple. The type-registering ticket is placed in a small metal tube just beneath the beam, and the poise is set at the desired weight, which in this case is 2,100 pounds, the capacity of the hopper.

Then the coal is released from the bunkers above into the scale hopper until the beam balances. The small hand lever at the bottom of the poise is then pulled forward, stamping the correct weight on the ticket. When the hand lever is released, the ticket moves forward one space ready to receive the next impression.

Finally the operator grasps the controller rope with one hand and the hopper gate lever with the other, and distributes the coal evenly in the hopper above the stokers. The type-registering ticket has space for 75 separate weighings, which is the maximum for an 8-hour shift.

At the end of each shift the ticket is removed and the weight totaled up, thus securing an undisputable record of the actual amount of the coal consumed. The scale can be easily run from one end of the building to the other in less than a minute, thus enabling the operator to feed the seven boilers without difficulty and obtain an accurate record of the coal used.

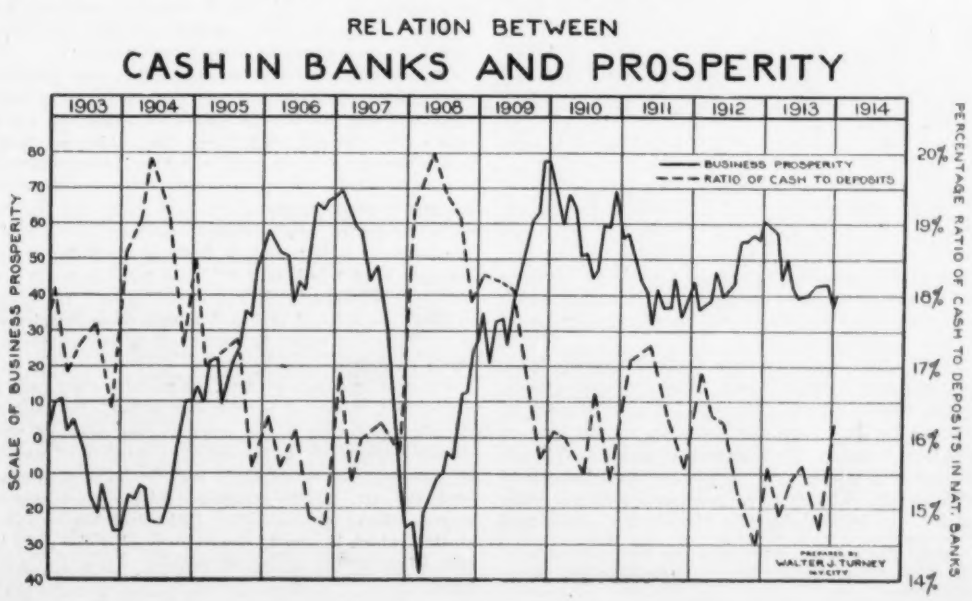
Alloy of Cobalt and Tin

THE official chemist of the American Institute of Metals reports that an alloy of about 40 per cent cobalt and 60 per cent of tin is especially resistant to acids, but owing to its brittleness it has little commercial value. Experiments, however, show that admixtures of this alloy with other metals, such as copper, produce a series of alloys which can be turned, forged, and machined, and still have a high degree of chemical resistance.—*American Machinist.*

A Graphic Representation of Economic Fluctuations

By Walter J. Turney

THE chart published herewith shows an interesting relation between the ratio of cash to deposits in national banks and business prosperity. It will be seen that this ratio is largest at about the time of severest business depression, and smallest at about the time of greatest prosperity. It is thus, broadly, an inverse measure of the country's prosperity. The solid line is a composite plot of business conditions based on bank clearings, new buildings, failures and other factors as combined and reduced to scale by Babson's Statistical Organization. The broken line is a plot of the ratio of cash to individual deposits in national banks for the whole country as figured from comptroller's reports.



Tropical Vegetable Foods*

Dietetics in Other Climes

By H. H. Rusby

It may be noted that the term "tropical," as used in this lecture, relates rather to climate than to latitude. When it is remembered that rising 200 feet in altitude has about the same effect on temperature as proceeding one degree toward the north or south pole, it becomes apparent that every climatic condition may be encountered in climbing the high mountains of Ecuador, directly under the equator. Millions of people there subsist chiefly upon vegetable products which can grow only in a cool-temperature or frigid region, and which could not properly be classed as tropical foods, although their growth and use is principally within the geographical tropics. For example, most people on learning that a majority of the people of Ecuador, Peru, and Bolivia subsist largely upon quinoa, would at once class this as an important tropical food, yet there is scarcely any other crop that requires so cool a climate. It is frequently partly covered with snow during the growing season, and its favorite climate is one too cold to permit barley-grains to develop upon their stalks. Potatoes, also, are very largely grown at these high altitudes, within the tropics, yet it is well known that potatoes can neither be grown nor successfully transported in tropical regions.

As a general thing, dwellers in the tropics eat rather sparingly of meat, and such meat is, like the people themselves, mostly lean. From this it might be assumed that the tendency is to avoid a carbonaceous diet, yet the reverse is true. Starchy foods and sugary fruits are mostly in demand. These foods are rather freely eaten, and it is not easy to understand what becomes of the carbon, since the people are rarely fleshy, and heat-radiation is at a minimum. As might be expected from the fermentation of such foods, intestinal diseases are very common, and constitute, in fact, the chief cause of death.

Among grains, Indian millet, Kaffir corn, or dhouro probably ranks first in extent of consumption in the tropics. First place is usually accorded to rice, but this is far too expensive an article for the poorer people, who sell it largely for export, and consume the cheaper and coarser millet. It is noteworthy that this grain is the seed of one variety of the same plant that yields our broom-corn and our sorghum sugar-cane. It is a more nutritious food than rice, which, contrary to popular lore, is of very low dietetic value. When eaten in the unpolished state, rice is much more nutritious, since its richest layer is just under the surface, and is removed in the polishing. Very often, however, insect eggs exist in this outer layer, and unpolished rice thus becomes subject to the attack of the weevil. Rice is more largely eaten in China and Japan, dhouro among the poorer classes of India and Africa. In the American tropics, maize or Indian corn is the chief grain. Travelers in Mexico always marvel at the vastness of the areas that they see planted with this crop. For miles upon miles the trains pass through fields of maize which reach as far as one can see in each direction. At short distances are little shelter boxes on stilts fifteen or twenty feet high, in which a watcher with a gun may be concealed and ready to shoot marauding trespassers. This corn, prepared in various ways, but mostly in tortillas, constitutes the staple food of the Mexican peon, and he certainly preserves a remarkable strength by its use. All through the South American tropics it is one of the staples, and is, in the parched state, the chief reliance upon long foot-journeys. In the more luxuriant regions, storage is not necessary, since it may be planted, and at the same time a crop harvested, upon any day of the year. It has numerous and destructive enemies, vegetable and animal, which attack both stalk and grain. The grain is specially liable to the attacks of worms, the larvæ from eggs deposited in the young grains. In many sections, especially in the Orinoco Valley, a natural breeding process has developed varieties with an extremely horny epidermis to the grains, which resists very effectively the pernicious efforts of the parasite egg depositor.

Among edible seeds and nuts, the bean probably holds the first place, if we include all of its numerous genera, species, and varieties. Otherwise, this place must be accorded to the peanut, for probably no one kind of bean is so largely used in the tropics proper. Although the peanut is largely consumed in the East Indies and British India, China doubtless uses more than any other country. In tropical America also, it is a staple food upon the table, and is introduced to a great variety of dishes. A sort of beer or fermented liquor is also made from it.

Throughout the Amazon Valley, the Brazil nut (*Bertholetia*), and to a less extent the monkey-cup nut (*Lecythis*), are similarly employed. These nuts, here known only as a table delicacy, constitute one of the staple foods of the aborigines, and are similarly used by the settlers. They are boiled, roasted, used as stuffing in fowls, in soups, hashed up with meat, and used in numerous other ways.

What maize is to the Mexican, rice to the Chinaman, and dhouro to the Kaffir, such is the coconut to the South Sea Islander. Not only does he cook it in a great variety of ways, but it yields butter for his cassava bread, fat for his cooking purposes, and even plain, fermented, and distilled beverages. The surplus, chiefly in the form of "copra," sold for export, yields a large part of his revenue.

Fats employed as butter-substitutes are yielded by many nuts and seeds of the old world tropics, a number of them belonging in the palm family. The cashew, or caju nut, in the sumac family, is one of the most delicious tropical products of its class. The entire fruit, when ripe, might be compared to a good-sized very juicy pear, with a single lima-bean, in a thick and hard pod, adhering to the end. The "pear" portion consists of the flower-stem, enlarged and fleshy, while the "bean" portion is the ripened ovary. The juice of the pulp, though very astringent, has excellent thirst-quenching properties, and is used in making a wine that closely resembles Madeira. The "bean" is shelled out, roasted and salted, and used like salted almonds, but is very much better than the latter. It is now to be purchased at many of our first-class grocery stores here in the United States.

The variety of beans, "pulse" of the Scriptures, cultivated in tropical countries, is quite bewildering, and the exact botanical origin of some of them is still in doubt. In Mexico the common red bean, or "frijole," is most used, although a small black bean is largely consumed. Both are true beans (*Phascoli*), but the garbanzo, almost as commonly served as the frijole, is *Cicer arietinum* L. In the subtropics, *Faba vulgaris*, the French, broad, or horse bean, is largely grown. It is a large bean, shaped like the lima, and is often roasted and salted for the table, or to be eaten out of hand, as our children eat peanuts. The lentil (*Ervum lens*) is one of the most ancient of foods, and is a great staple in the Orient, especially in Egypt. In southwestern Asia and northern Africa, the related plant *Trigonella* yields a bean-like seed that is different from all others in the family. It is not only richly albuminous, but contains an alkaloid that gives it a bitterish taste, and renders it stomachic and tonic. The pigeon-pea, *Cajanus Indicus*, is another small bean that is delicious, as well as very nutritious and wholesome. It is largely grown in the West, as well as in the East Indies. In China, the Soy bean (*Soja*) is a very important product. It requires an experienced cook to make it palatable, but the Chinaman produces with it some remarkably savory dishes. It contains a disagreeably smelling and tasting fatty oil. This is removed and used for technical purposes. The remainder, being free from starch, is much eaten by diabetic patients.

Of tropical root-crops, among which are included tubers, bulbs, and corms, as well as true roots, the most important are the several species of yams, the sweet potato, the Cassava, and Taro. The white, or Irish, potato cannot be grown with advantage, even where it is able to exist. Its tubers become watery and sweetish, and it decays within a few days after being dug, or even transported into a tropical climate. The Andean mountaineers have a way of freezing the water out of potatoes, after which they exhibit a corky dryness, and will keep indefinitely. In this condition they are easily carried into tropical regions. I have some samples of this "Chunya," made in 1884, which are in perfect edible condition.

The sweet potato, a plant in the morning-glory family, is too well known to require description. Its cultivation is world-wide in the tropics. The yam, of very similar appearance, is yielded by a number of species of *Dioscorea*. Some of these varieties give off prussic acid and are fatally poisonous, with almost instantaneous effects, if eaten before this poison has been dissipated, which is usually done by exposing the roots in thin slices to the action of running water for some hours.

The same poison is produced in the bitter cassava, or manihot, the cultivation of which is general in tropical America and common in other tropical regions. For this reason it is rarely eaten. Its starch is extracted and forms the tapioca of commerce. Sweet cassava, from another species of Manihot, is very largely eaten, as well as used for the extraction of tapioca. It is a large fusiform root like a very large dahlia root. It is the great root-crop of tropical America, and is eaten boiled, baked, and roasted in the ashes, and is also ground up into a flour from which cassava bread is made. This bread is noted for its keeping qualities. It may be carried about by travelers for months, or even years, if some care is taken with its storage. Sago is a very similar starch to tapioca, but is made in the East Indies from the soft inner portions of the trunks of a number of plams. Most of the article sold for sago in this country is really tapioca. True sago is of a reddish color. The flavor of the two is very similar. Arrow-root is a very expensive starch, made from the rootstock of *Maranta*, and mostly produced in the West Indies. It is popularly supposed to have special nutritive, or even curative properties, but differs not from other starches in those particulars. A spurious arrow-root starch is made in the West Indies and Florida from one or more species of *Zamia*. It is mostly used in making so-called arrow-root crackers of American manufacture.

Of all the tropical vegetable foods, and indeed most important of all vegetable foods, is the banana, destined to become eventually the chief food of the poorer classes of the entire world. The ripe banana, while a delicious dessert fruit, is not adapted to use as a common food, by virtue of its strong and sweet flavor, and also its relative indigestibility. The same fruit, however, boiled, baked, or roasted when about three fourths grown, has very much the flavor of a baked potato, with scarcely any sweetness, and is nutritious, non-cloying, and perfectly digestible. The amount of this food that can be grown on an acre per year is so much in excess of any other as to make any comparison with other crops rather ridiculous.

The importance as foods of the bread-fruit and Jack-fruit, in Eastern countries, is very generally known. They are produced by species of *Artocarpus*, in the mulberry family. Like the green banana, they owe their staple value largely to their freedom from sweetness or other pronounced flavor, so that one does not tire of them when continuously eaten.

Many tropical fruits which are really sugary, like figs and dates, are so generally and extensively eaten that they may be properly regarded as foods proper, rather than as dessert fruits. The subject of tropical fruits is so extensive that it should be treated in a separate article, and this brief reference to the subject must suffice on the present occasion.

* Abstract of a lecture delivered at the New York Botanical Garden and published in the *Journal of the New York Botanical Garden*.

Fluids With Visible Molecules

By Prof. Jean Perrin

The kinetic theory of gases gives an approximate means of determining the actual dimensions of the molecule, and Maxwell obtained an expression for Avogadro's constant N, from considerations connected with the viscosity of gases. The Brownian movement of visible microscopic particles appears to be the result of molecular agitation, and any particle in suspension seems to function as an enormous molecule. If this is so, the gas laws, already extended by van 't Hoff to solutions, must also apply to dilute emulsions composed of equal grains, and if the osmotic pressure of this "gas with visible molecules" is known, Avogadro's Law will give the ratio of the masses of the grains to those of the invisible molecule of any gas. In an indefinite vertical column of emulsion in equilibrium the osmotic pressure at any level counterbalances the weight of the higher layers, as in a heavy gas, and the emulsion is a miniature atmosphere. If, then, it is necessary to rise a hundred million times less than in oxygen in order to double the rarefaction, it may be concluded that the visible grain is a hundred million times heavier than the molecule of oxygen. In order to obtain equal grains, emulsions made by precipitating alcoholic solutions of resin with water were submitted to a process of fractional centrifugalization. These emulsions obey the gas laws, and the value of Avogadro's constant N can be calculated from them. It is found that the value of N thus found is

* Abstract in the *Chemical News* of a course of lectures delivered at King's College, London.

independent of the size of the particles, and agrees with the number given approximately by the kinetic theory (68×10^{22}). The Law of Gay Lussac holds good for temperatures between — 10 degrees and + 60 degrees. Since dilute emulsions follow the gas laws it is probable that concentrated emulsions would behave like compressed fluids and that van der Waals' theory could be applied in studying them. To determine the osmotic compressibility of the emulsion (i. e., the variation of the osmotic pressure as a function of the concentration of the grains) it is necessary to observe the distribution in a vertical column of emulsion all the grains of which have been counted. The osmotic pressure at each level, supporting all the grains above this level, is thus determined. (The emulsion is its own manometer.) It is then easy to determine whether the pressure P thus obtained satisfies van der Waals' equation:

$$\left(P+\frac{a}{V^2}\right)\left(V-b\right)=RT$$

where R = gas constant.
T = absolute temperature.
V = volume of emulsion containing N grains.
b = four times the volume of these grains.
a = a constant corresponding to the cohesion.

If this is the case, the observation of a concentrated emulsion will give Avogadro's number. Experiment verifies this prediction; it is found, however, that the constant of cohesion is negative, and that the grains repel one another to an appreciable distance. This result permits of the experimental determination of the thickness of the double layer of electrification by contact, and throws light upon the properties of colloidal solutions. A knowledge of the compressibility also provides a verification of the theory of Smoluchowski on the spontaneous fluctuations of the density of a fluid in a given volume. The activity of the Brownian movement is defined as the quotient $\frac{E^2}{t}$, where E^2 is the mean square of the displacement in time t. An emulsion should diffuse like a solution of visible molecules with a speed which is greater the greater the speed of the molecules composing it. By calculation it is found that the coefficient D of diffusion is obtained by dividing the activity $\frac{E^2}{t}$ by 6, and since at any level as many molecules pass upward by diffusion as pass downward by gravitation the coefficient of diffusion depends upon the radius r of the grains and the viscosity z. Thus Einstein's equation holds, viz.:

$$\frac{E^2}{t}=6\,D=\frac{RT}{N}\,\frac{1}{\pi r z}$$

Thus Avogadro's constant can be determined both by measuring the diffusion and by measuring the displacements. In order to study the diffusion, emulsions were obtained which were such that the grains remained attached to the walls of the vessel when they came in contact with them. The emulsion thus became progressively weaker by diffusion, and the coefficient of diffusion was given by the increase of the number of grains captured as a function of the time. The displacements of spherules of known radius can be measured very easily, and these measurements, made in very varying conditions as regards the size of the grains and the nature of the intergranular liquid, all gave concordant results for Avogadro's number. Moreover, with relatively large spherules it is easy to measure the rotations and thus verify Einstein's formula for the Brownian movement of rotation. All these theories apply to granules suspended in a gas, except that Stokes's law no longer holds good. By applying an electric field Townsend's equation for the diffusion of gaseous ions connects the charge e on the granule with Avogadro's number and with the activity of its Brownian movement, viz.:

$$Ne=\frac{RT}{D}\,\frac{u}{H}=6\,RT\,\frac{t}{E^2}\,\frac{u}{H}$$

The verification of these formulæ giving for the product Ne simple multiples of the faraday shows that the charge of microscopic particles is an integral multiple of the same charge (equal to that of the hydrogen ion in electrolysis).

The following table shows the results obtained by the different methods briefly described above:

	Quotient $N/10^{22}$
Viscosity of gases	62
Brownian movement of translation	69
Brownian movement of rotation	65
Fluctuation	60
Electric charge of droplets	65
Radio-activity	62 to 65

Calculating Heat Losses from Buildings*

By Charles L. Hubbard

THE first step in the consideration of any system of warming, whatever its type, is to determine the heat loss from each room in British thermal units per hour. This depends upon the character and extent of the exposed surface, the difference between the inside and outside temperatures and the points of the compass.

The buildings considered in the present article may be included in four general classes, according to their construction and heat requirements. Class 1 includes office and municipal buildings, hotels, hospitals, theaters, schools, loft buildings, etc., where the walls are constructed of brick or stone with an inside furring of lath and plaster, and in which a normal temperature of 70 degrees is desired.

Class 2 includes shops and factories of brick or concrete, without furring, usually several stories in height, and also requiring a temperature of 70 degrees.

Class 3 includes shops of modern design having walls of brick or concrete and thin roofs of different construction. Buildings of this type are usually heated to 60 degrees.

Class 4 includes foundries, boiler and forge shops, etc., covered entirely, or in part, with corrugated iron, and heated to 50 degrees.

These different classes of buildings will now be taken up in order, with tables and data for computing the heat loss from each within the usual range of conditions.

Class 1.—For buildings in this class the following data may be used:

TABLE 1.—(WALL SURFACE.) HEAT LOSS IN B.T.U. PER SQUARE FOOT OF SURFACE PER HOUR FOR A TEMPERATURE DIFFERENCE OF 70 DEGREES.

Solid Brick Wall with Lath and Plaster Furring and Air Space.	Heat Loss in B.t.u.
8-in. brick	18
12-in. brick	16.5
16-in. brick	15
20-in. brick	12.5
24-in. brick	11
28-in. brick	10

For brick walls with sandstone face, 4 to 8 inches in thickness, plastered inside, but without furring or air space, multiply the factors in Table 1 by 1.3. For stone walls instead of brick, multiply the factors in the table by 1.3.

TABLE 2.—(GLASS SURFACE.) HEAT LOSS IN B.T.U. PER SQUARE FOOT OF SURFACE PER HOUR FOR A TEMPERATURE DIFFERENCE OF 70 DEGREES.

Character of Surface.	Heat Loss in B.t.u.
Single sash	84
Double sash	42
Single skylight	91
Double skylight	46

For other temperature differences than 70 degrees, multiply the factors in Tables 1 and 2 by the following: For 50 degrees multiply by 0.71; 60, 0.86; 70, 1; 80, 1.14; 90, 1.30.

In addition to the heat loss by transmission there is also a certain amount due to leakage, depending upon the tightness of the building construction, especially around doors and windows. This may be provided for in the average well-built structure by multiplying the transmission loss by 1.2. For public rooms, where there is a good deal of passing in and out, it will be necessary to use a larger factor, depending upon local conditions. In main lobbies and similar rooms a factor of 1.5 to 2 is often required.

Corrections for different points of the compass should be made as follows: For north exposure, multiply by 1.3; east, 1.1; south, 1; west, 1.2.

In rooms of considerable height the heat loss is increased on account of the higher mean temperature and the more rapid circulation of the air over the cool surfaces. This amounts to about 2 per cent for each additional foot above 12 feet in height.

Although in office buildings the walls are reduced in thickness on the upper floors, it is not usually necessary to enlarge the radiators on this account, because the warm air, rising, is generally sufficient to offset any increase in heat transmission due to this cause. For very tall buildings, however, where the upper floors are more exposed to the wind, it may be necessary to allow for the thinning of the walls and also increase the factor for leakage.

When there is a low attic or roof space in which steam pipes are carried, no additional radiation is required to offset a cold ceiling on the upper story. In case of a roof space without steam pipes, increase the radiation about 15 per cent. When there is a solid roof, without air space, use the factor from Tables 4 or 6, which corresponds most nearly to the actual conditions.

EXAMPLE: A room in an office building has a wall exposure of 450 square feet and a glass exposure of 100 square feet. The walls consist of 8 inches of brick, with sandstone facing, plastered on the inside. The windows have single sashes and the exposure is east. What will be the total heat loss per hour for a temperature difference of 70 degrees?

Factor for wall, 18 × 1.3	= 23.4
Factor for window	= 84
Factor for leakage	= 1.2
Factor for exposure	= 1.1

from which the total heat loss is found to be

$$[(450\times23.4)+(100\times84)]\times1.2\times1.1=24{,}987\text{ B.t.u.}$$

Class 2.—Buildings of this type are usually of solid brick or of concrete, without insulating finish of any kind upon the inside walls, except in special rooms, such as offices, drafting rooms, etc.

TABLE 3.—(WALL SURFACE.) HEAT LOSS IN B.T.U. PER SQUARE FOOT OF SURFACE PER HOUR FOR A TEMPERATURE DIFFERENCE OF 70 DEGREES.

		Heat Loss in B.t.u.
Solid walls,	8-in. brick	31
	12-in. brick	22
	16-in. brick	18
	20-in. brick	15
	24-in. brick	14

For reinforced concrete, multiply the factors in Table 3 by 1.3. For ordinary wooden construction, with paper and clapboards on the outside and lath and plaster on the inside, use a factor of 21 for a temperature difference of 70 degrees. For roof construction of different kinds use Table 4.

TABLE 4.—(ROOF SURFACE.) HEAT LOSS IN B.T.U. PER SQUARE FOOT OF SURFACE PER HOUR FOR A TEMPERATURE DIFFERENCE OF 70 DEGREES.

Roof Construction.	Heat Loss in B.t.u.
Slate or matched boards	21
Iron or matched boards	12
8-in. hollow tile, 1-in. concrete, tar and gravel	28
6-in. concrete, cinder fill, tar and gravel	38

For window surface, see Table 2.

With wooden sashes the factor for leakage may be taken as 1.3, while for iron sashes, which are much tighter, it may be reduced to 1.10.

In shops and factories where the floors are undivided by partitions, and the walls exposed to all four points of the compass, a factor of 1.16 may be used when correcting for exposure.

For other temperature differences than 70 degrees, use the factors given under Class 1.

Class 3.—The conditions here are much the same as in Class 2, except that the entire building is treated as a single room and a lower inside temperature is maintained.

TABLE 5.—(WALL SURFACE.) HEAT LOSS IN B.T.U. PER SQUARE FOOT OF SURFACE PER HOUR FOR A TEMPERATURE DIFFERENCE OF 60 DEGREES.

		Heat Loss in B.t.u.
Solid walls,	4-in. brick	40
	8-in. brick	26
	12-in. brick	19
	16-in. brick	16

For reinforced concrete multiply the factors in Table 5 by 1.3.

TABLE 6.—(ROOF SURFACE.) HEAT LOSS IN B.T.U. PER SQUARE FOOT OF SURFACE PER HOUR FOR A TEMPERATURE DIFFERENCE OF 60 DEGREES.

Roof Construction.	Heat Loss in B.t.u.
Patent roof (tar and gravel)	18
6-in. hollow tile, 2-in. concrete, tar and gravel	22
4-in. concrete, cinder fill, tar and gravel	36
Unlined metal	78

For tile and concrete floors on earth use a transmission factor of 6 for ordinary conditions.

For single windows and a temperature difference of 60 degrees, use a transmission factor of 72.

Leakage may be treated the same as in Class 2, using the factors 1.3 and 1.1 for wooden and iron sash, respectively.

The factor for exposure may be taken as 1.16, considering the whole building as a single room.

Class 4.—Buildings of this type are confined chiefly to foundries, boiler shops, forge shops, etc., where the normal inside temperature may be comparatively low. Tests show that the transmission losses through unlined corrugated metal are nearly the same as for a single window, and for all practical purposes no distinction need be made between the walls, windows or roof in buildings of this kind.

Taking the transmission factor as 65 for a temperature difference of 50 degrees, and multiplying by 1.3 and 1.16 for leakage and exposure, respectively, gives a total loss of

$$65\times1.3\times1.16=98.02\text{ B.t.u.}$$

per square foot of gross area per hour. To this should be added a transmission of about 5 British thermal units per square foot of floor area.

In general, a heat loss of 100 British thermal units per square foot of gross wall and roof area will safely cover all ordinary conditions where the outside temperature does not drop much below zero.

*Reproduced from *Power*.

Sugar as a Surgical Antiseptic has been recommended by an eminent German surgeon; although all saccharine substances are good, pure cane or beet sugar is best. It is said that it is not injurious to the blood, and is a better preventive of putrefaction and contamination by microbes than ordinary medical antiseptics.—*Science Conspectus.*

Compression Tests on Woods*

Mahogany and Teak Head the List in Strength

By Percy W. Smith

THE tests of which this article forms the subject matter have been conducted in the Mechanical Engineering Department of the Northampton Polytechnic Institute, Clerkenwell, E. C. The machine used for testing, as will be seen from Fig. 1, is a Wicksteed vertical single-lever machine having a low lever ratio of less than 100 to 1. A maximum load of 150,000 pounds can be imposed on the specimen, and the poise weight for giving this load is under electrical control or can be alternatively hand controlled when required, while the straining is effected by hydraulic pressure from high-pressure mains. Immediately in front of the operator a pointer attached to the steelyard lever is placed, showing to a magnified scale the movement at the end of the steelyard. The plattens used for compression tests are of the usual flat plate type and are shown in Fig. 2. It is worthy of note that the seating to which the top and movable compression platten is attached, and which is connected to the hydraulic ram, is spherical in form, and is therefore automatically adjusted so that the pressure becomes exactly normal to the two faces of the specimen between the plattens. This is a very necessary condition and ensures greater accuracy in the results obtained. The poise weight was operated electrically during the tests recorded so as to obtain a uniform rate of loading which approximated to 300 pounds per second, and the rate of straining was adjusted by the hand-regulating valve, keeping the indicator pointer central, and ensuring the steelyard being practically balanced in its horizontal position throughout the tests.

Timber in its different qualities is so largely used for building and structural purposes that reliable test results on its strength and properties under various straining actions afford information of much practical value to the builder and engineer. Probably the most useful and reliable of the simpler tests to which timber can be subjected are to be obtained from crushing short blocks in the direction of the grain. Crushing at right angles to or across the grain is not so reliable, and does not yield very definite results, and seems to depend on the amount of deformation, there being no well defined point of failure. It will be seen from a perusal of the results given, as might be expected, that the strength along the grain is very much greater than the strength across the grain. In the former case the strength of the whole block depends on the combination of the strengths of the several fibers, while in the latter case the strength of the block depends for the most part on the adhesion of the fibers. In practice, all timber used as struts or ties is arranged whenever possible so that the force to which it is subjected acts with the grain structure. When crushed along the grain failure generally occurs, in the case of short blocks, by a combined shearing and buckling of the fibers. The tendency is then to fail over the whole of an internal surface inclined to the direction of pressure.

The theory of elasticity is of some importance in this connection, in that it proves that the greatest shear or tangential stress in the case of a material stressed up to its elastic limit takes place in a plane inclined at 45 degrees to the direction of the pressure. For, consider the case of an element of material *A B C D*, Fig. 3, and any oblique section under the straining action of equal and opposite forces of uniform intensity. Let the total stress or load be represented by P and the intensity of stress by p. the inclination of the normal to the axis of the specimen being θ. Resolving normally and along the plane *E F* we obtain $P \cos \theta$ and $P \sin \theta$, the former being the compressive stress at right angles to the oblique plane and the latter the tangential or shear stress in the plane. The intensities of these normal and tangential stresses are found by dividing the above results by the area, $a \sec \theta$, of the oblique section plane, where a denotes the area of the principal cross-section of the element. That is

$$p_n = \frac{P \cos \theta}{a \sec \theta} \text{ and } p_t = \frac{P \sin \theta}{a \sec \theta}$$

or $$p_n = \frac{P}{a} \cos^2 \theta \text{ and } p_t = \frac{P}{a} \sin \theta \cos \theta$$

or $$p_n = p \cos^2 \theta \text{ and } p_t = p \sin \theta \cos \theta$$

Now, p_t has its maximum value when $\sin \theta \cos \theta$ is a maximum; that is, when $\theta = 45$ degrees.

Fig. 1.—Wicksteed vertical single-lever testing machine.

This theory would indicate elastic failure, in the case of short blocks, along these planes of maximum shear stress, that is, at 45 degrees; but in the case of crushing tests to destruction the angle varies on both sides of this value, due to other causes which it is not proposed to deal with in this article. The right-hand views of Figs. 4 and 5 show planes of shear failure very closely defined.

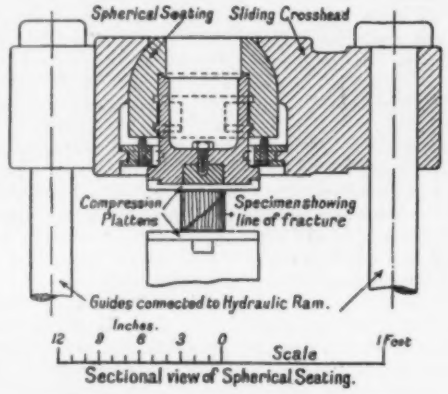


Fig. 2.—Plattens for compression tests.

Sometimes the failure is partly due to a vertical splitting combined with the shearing action already explained, and can be seen in the right-hand views of Figs. 6, 7, and 8. Fig. 11 shows failure by vertical splitting, crushing and buckling; this seldom occurs, however, and these

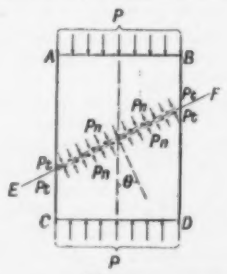


Fig. 3.

are the only two such failures from upward of one hundred tests. The specimen on the left of this figure is oak and on the right birch, both having been tested with the grain; these specimens had been well dried artificially before testing, and this probably accounts for the vertical splitting and buckling to such a degree. Fig. 12 shows two pieces of mahogany. The piece on the left was tested diagonally and failure occurred, as will be seen, by central splitting at a comparatively low load. In the right-hand view of the same figure, the grain was not exactly in the direction of pressure, and failure occurred by splitting or shear into four pieces in the direction of the grain. In Figs. 4 and 6–10, the left-hand views show specimens tested across the grain, and the manner of failure is obvious. In all the specimens shown, the original size of each was 3 inches by 3 inches by 3 inches, and by comparison with the 3-inch scale shown centrally the amount of compression can be observed.

In the majority of cases when tested along the grain, and after failure had occurred, the specimen would stand about three quarters of the original crushing load, but with a large amount of compression, although before failure occurred very little deformation was observed. The pointer indicating the movement of the steelyard was most interesting to watch at this stage; rising and falling in successive intervals, showing that the specimen held the load for a short time and then compressed slightly, when it would again hold the same load and again compress, and so on. This was also noticeable in the case of testing across the grain, and although the initial point of failure was very low, frequently as much as 100,000 pounds was put on the specimen, the amount of compression then being about 2 inches. On releasing the load in both cases of testing, there was considerable recovery or spring in the specimens, sometimes over 1 inch being noticed, showing that although the specimen had failed as a whole, constituent fibers still retained a considerable amount of elasticity. Fig. 13 shows a typical stress-compression diagram for a 3-inch cube, from which the behavior of the specimen throughout a test may be readily understood.

Referring now to the tables as set out, Table I gives the average crushing stresses for each wood in order of magnitude. The comparative strengths of the woods tested are shown in the last column, the weakest wood being taken as representing unity.

In Table II are given results for the same woods, in one case tested along the grain and in the other case when tested across the grain. Column 4 of this table shows the ratio of strength across to strength along the grain, which, as will be seen, is comparatively small.

Table III shows the effect of soaking the specimens in water for periods of one and two weeks, after which they were tested for crushing strength similarly to the specimens in the ordinary condition. In columns 4 and 6, the ratio of the crushing strengths when wet to the crushing strengths when dry are given for soaking periods of one and two weeks respectively. It will be seen that when soaked for one week elm and teak stand well clear of the other timbers, and that after a further week of soaking the elm has a still greater advantage over teak even, although having again decreased slightly itself in value. From these results, it is obvious that for working in water elm holds pride of place, with teak a good second, the majority of the other timbers being more or less of a sameness farther down the scale. It is quite probable, however, that being kept constantly under water does not seriously injure some woods, but that after alternate wetting and drying for some little time they soon lose their durability.

In Table IV are shown the ratios of the crushing strengths in pounds per square inch to the weights of the corresponding woods in pounds per cubic foot. As will be seen from column 5, these ratios tend to approximate to a constant quantity, which, for practical purposes, may be stated as 165. That is to say, knowing

* Reproduced from *The Engineer*.

Fig. 4.—American oak.

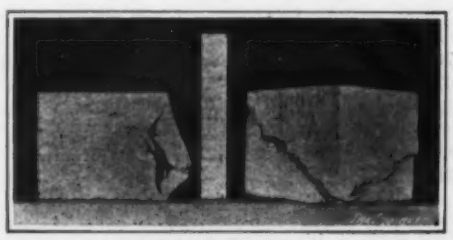


Fig. 5.—Birch.

Fig. 6.—Pitch pine.

Fig. 7.—Teak.

Fig. 8.—Mahogany.

Fig. 9.—Ash.

the weight of a timber in pounds per cubic foot, we can, by multiplying by 165, find the approximate crushing strength in pounds per square inch. Fig. 14 shows a diagram in which the crushing strength per square inch is plotted on a base representing weight in pounds per cubic foot. As would be expected from the fact of the ratios being practically constant, the relationship between the two plotted quantities follows a straight line law.

TABLE I.

Species of wood.	Average strength lbs. per sq. in.	Comparative strength, weakest wood taken as unity.
Mahogany	7430	1.5
Teak	7420	1.5
Yellow deal	6960	1.4
Ash	6330	1.28
American white	5880	1.18
Birch	5800	1.17
Beech	5470	1.1
Elm	5300	1.07
American oak	5050	1.02
Pitch pine	4960	1.00

TABLE II.—*Comparison of Crushing Strength Across the Grain to Crushing Strength With the Grain.*

Wood.	Crushing strength with grain, lbs. per sq. in.	Initial crushing strength across grain, lbs. per sq. in.	Ratio, strength across / strength with
Mahogany	7430	1940	0.26
Teak	7420	1720	0.23
Yellow deal	6960	750	0.11
Ash	6330	730	0.11
American white	5880	1400	0.24
Birch	5800	1350	0.23
Beech	5470	930	0.17
Elm	5300	1060	0.2
American oak	5050	2010	0.4
Pitch pine	4960	830	0.17

TABLE III.—*Showing Effect of Water Soaking on Crushing Strength.*

Wood.	Average crushing strength (dry state), lbs. per sq. in.	After one week soaking.		After two weeks' soaking.	
		Crushing strength, lbs. per sq. in.	Ratio, strength wet / strength dry	Crushing strength, lbs. per sq. in.	Ratio, strength wet / strength dry
Mahogany	7430	4960	0.69	4500	0.6
Teak	7420	6780	0.91	5670	0.76
Yellow deal	6960	3680	0.53	2670	0.38
Ash	6330	4050	0.64	3000	0.48
American white	5880	3820	0.65	3230	0.55
Birch	5800	3330	0.57	3090	0.53
Beech	5470	3670	0.67	3330	0.61
Elm	5300	4980	0.94	4670	0.88
American oak	5050	3550	0.7	3000	0.59
Pitch pine	4960	4000	0.8	2390	0.48

TABLE IV.—*Showing Ratio of Crushing Strength in Pounds per Square Inch to Weight of Wood in Pounds per Cubic Foot.*

Wood.	Average weight of 3-in. cubes, lbs.	Weight in lbs. per cubic foot.	Average crushing strength, lbs. per sq. in.	Ratio, crushing, lbs. per sq. in. / weight, lbs. per cub. ft.	Average constant.
Mahogany	0.7	44.8	7430	166	
Teak	0.7	44.8	7420	166	
Yellow deal	0.63	40.3	6960	173	
Ash	0.6	38.4	6330	165	
American white	0.55	35.2	5880	167	164.6 say 165
Birch	0.54	34.6	5800	168	
Beech	0.55	35.2	5470	155	
Elm	0.5	32	5300	166	
American oak	0.5	32	5050	158	
Pitch pine	0.48	30.7	4960	162	

To sum up, we can say, then, that in the case of timbers free from knots and other defects the crushing strength is proportional to the density.

Timber is more variable than any other material with which the builder or engineer has to deal, and even in specimens from the same tree, test results vary widely. So large a variation is perhaps due to the various differences in external and internal conditions occurring during and after growth. Soil and climate have a large influence on the ultimate material; also the age of the tree and the season of felling are factors to be taken into consideration, while the duration of the seasoning process is probably the chief point to be observed. The strengths of many woods also are practically doubled by a correct process of seasoning.

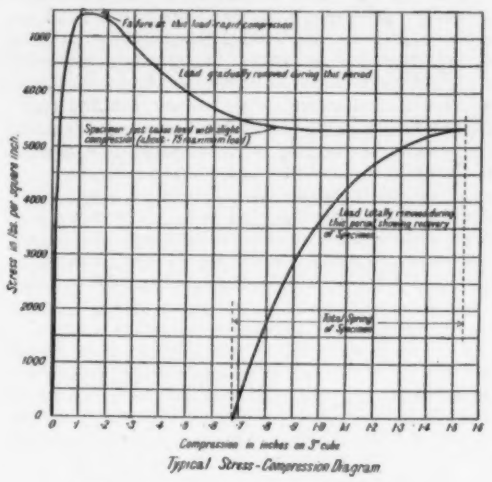

Failure at the load rapidly compressed
Load gradually removed during the period
Specimen just takes load with slight compression (about 75 per cent maximum load)
Load totally removed during short period, showing recovery of Specimen
Total Spring of Specimen
Stress in lbs. per square inch.
Compression in inches on 3" cube
Typical Stress-Compression Diagram

Fig. 13.—Stress-compression curves.

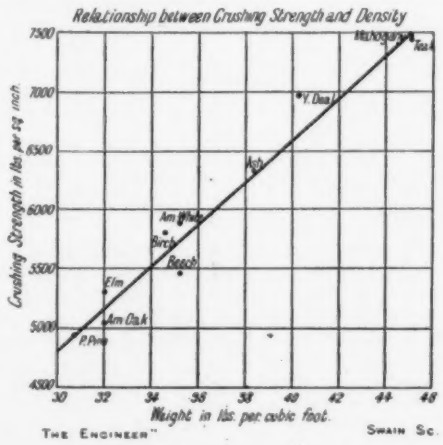


Fig. 14.—Crushing strength and density.

In taking account of the results given in this article, it should be borne in mind that the specimens are not selected ones. The majority of results given on the strengths of woods are usually taken from specially selected timbers, and thus the strengths are abnormally high. The test results given here have extended over a fairly long interval of time, and have been made on timbers direct from the merchant, without special consideration or selection as to good or bad pieces, and, although bought at different periods—and, consequently, from different sources—the results agree, and average up well. From a practical point of view these results, then, should be more useful than those obtained from specially selected specimens.

The author, in conclusion, wishes to thank Mr. C. E. Larard, M. Inst. C. E., head of the Mechanical Engineering Department, for the facilities given for making the tests and for helpful criticism.

The Wine Production of Greece

THE production of wine and of the small seedless variety of grapes known as currants is the most important industry of Greece. The annual yield of the vineyards and currant plantations is valued at $20,000,000. Although it is essential to distinguish between the yield of the vineyards proper and that of the plantations devoted to the production of dried currants, which are the chief export of the country, the distinction tends to lose its importance owing to the fact that a larger quantity of fresh currants is being produced for wine-making each year, according to the United States Consul at Athens. The area planted with vines is about 346,000 acres, with an average total annual production of 66,000,000 gallons, while the currant plantations cover an area of 185,000 acres, producing annually about 160,000 tons of dried currants. The vintage of 1912 was exceptionally good, both in quantity and quality, exceeding that of the previous year by about 25 per cent, while the production of must is estimated at 688,000,000 pounds as against 551,000,000 pounds in 1911. The general mobilization, coming at the busiest season of the year, deprived the wine and currant producers of manual labor; also the requisition of the railways and merchant marine by the government for transport services, combined with the increased cost of fuel and high freights, could not fail to affect this industry unfavorably. The total production of wine during 1912 was about 66,000,000 gallons, which is up to the annual average. There are four distinct categories of wines produced in Greece: (1) Dark red wine, which is almost exclusively employed for blending, and is characterized by a deep red color and strong tannic and astringent properties. These wines are generally exported either in their natural state or mixed with other wines, in order to increase their percentage of alcohol and retain their color and character. (2) White table wines, mostly used for home consumption, after the addition of a ferment of pine resin ranging from 2 per cent to 6 per cent. This resinated wine is highly esteemed by the Greeks as a febrifuge, but its pronounced flavor of turpentine does not appeal to foreigners, who have not accustomed their palates to its peculiar taste. The practice of adding resin dates from Roman times, and is used to preserve the wine and promote natural fermentation. A considerable quantity of white wine is exported, without the addition of pine resin. (3) Ordinary red wines of various qualities and flavors, depending generally upon the districts of production. These wines are consumed locally and are also exported. They are dry or slightly sweet, and highly alcoholic; they are still wines, and generally possess sufficient bouquet and flavor. (4) Dessert-wines and liqueurs, mostly white or golden in tint, but rarely red. Their composition is exclusively due to fermentation, and they are produced from the finest qualities of grapes, no other ingredients being used. Important quantities are exported to foreign countries.—*Journal of the Royal Society of Arts.*

Fig. 10.—Yellow deal.

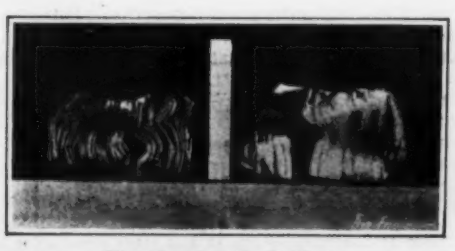


Fig. 11.—A, oak; B, birch.

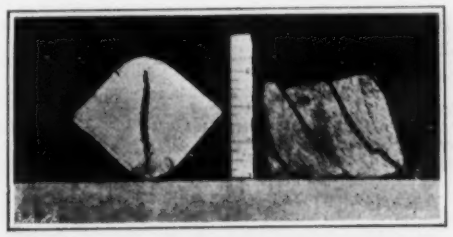


Fig. 12.—Mahogany.

The Solar System and the Earth's Crust*

Essential Similarity in Composition of Sun and Earth

By Prof. Henry Norris Russell

Prof. Rowland's list of the elements whose lines appear in the solar spectrum has long been a classic work of reference among astronomers, and Dr. F. W. Clarke's summary of the chemical composition of the earth's crust occupies a similar position among geologists. Each list has been thoroughly discussed, by various writers, from the standpoint of the science to which it belongs; but little attention seems to have been called to the striking resemblances between the two.

In the annexed table are given (1) Rowland's list of the elements whose dark lines appear in the integrated spectrum of the sun, arranged in the order of the combined intensity of the lines of each element, as quoted in Abbot's "The Sun," p. 91, (1911); (2) a similar list of the elements, arranged in the order of the intensity of their bright lines in the spectrum of the solar atmosphere, as photographed at the total eclipse of 1905 by S. A. Mitchell[1]; (3) Clarke's table of the percentage composition of the outer ten miles of the earth's substance, including the lithosphere, hydrosphere, and atmosphere,[2] and (4) the average composition of ninety-nine stony meteorites, as derived by G. P. Merrill from published analyses.[3]

Solar Spectrum, Dark Lines (Howland)		Chromosphere, Bright Lines (Mitchell)	Earth's Crust, Outer 10 Miles (Clarke)		Stony Meteorites (Merrill)	
1	Ca	Fe	O	49.85%	O	35.75%
2	Fe	Ti	Si	26.03	Fe	24.52
3	H	H	AL	7.28	Si	18.20
4	Na	Cr	Fe	4.12	Mg	13.80
5	Ni	Ca	Ca	3.18	S	1.85
6	Mg	V	Na	2.33	Al	1.45
7	Co	Sc	K	2.33	Ca	1.25
8	Si	Zr	Mg	2.11	Ni+Co	1.32
9	Al	C	H	0.97	Na	0.70
10	Ti	Mn	Ti	0.41	Cr	0.34
11	Cr	Mg	Cl	0.20	K	0.27
12	Sr	Ni	C	0.19	P	0.11
13	Mn	Co	P	0.10		
14	V	Nd	S	0.10		
15	Ba	He	F	0.10		
16	C	Co	Ba	0.09		
17	Sc	Y	Mn	0.08		
18	Y	Sr	Sr	0.03		
19	Zr	Ba	Cr	0.025		
20	Mo	La	Ni+Co	0.018		
21	La	Sa	V	0.015		
22	Nb	Al	Zr	0.013		
23	Pd	Er	Cu	0.010		
24	Nd	Gd	Zn	0.004		
25	Cu	Na	Li	0.004		
26	Zn	Si	Pb	0.002		
27	Cd	Eu	Br	0.0006		
28	Ce	Zn	As	0.0004		
29	Gl	Dy	Cd	0.00002		
30	Ge	Cu				
31	Rh	Pr	Allowance for all other elements 0.38			
32	Ag	Nh				
33	Sn					
34	Pb					
35	Er					
36	K					

All these lists are doubtless incomplete at the lower end. Later researches have shown that oxygen, gallium, ruthenium, and all the rare earths given in Mitchell's list, should be added to Rowland's table, raising the number of elements represented to 45.

The presence of nitrogen is also indicated by the appearance of the cyanogen bands, but not by its own lines. Photographs showing fainter lines would probably considerably extend the list of elements recognizable in the flash-spectrum. The list of elements in the earth's crust is certainly very incomplete below those which form 0.01 per cent of the total. If carried out to the limit it should of course include all the elements, and it is not yet known what positions some of them, such as the rare earths, would occupy in a complete scheme. The list for the stony meteorites is probably far from exhaustive, and it is not safe to draw conclusions from the failure of some elements to appear in it. It may be added that, according to Farrington,[4] the average percentage of nickel in meteoric irons is about 7.5, and that of cobalt about one tenth as much, while that of copper averages about 0.02. It would therefore seem reasonable to suppose that the amounts of "Ni + Co" given in the table should be divided between the two metals in about this ratio.

Upon comparing the lists of Rowland and Clarke, we meet at once the fact—one of the commonplaces of astrophysics—that the non-metallic elements, with the exception of carbon and silicon, are scarcely if at all represented in the solar spectrum. The only one whose lines appear is oxygen—which is from 20 to 100 times more abundant in accessible materials than all the others put together (excepting C and Si, as above). If we simply accept this fact (which is still without adequate explanation), and exclude these non-metallic elements from the comparison, the similarity between the order of the remaining elements in the two lists is remarkable.

Of the eight metallic elements (including carbon and silicon under this head for the moment) which are most abundant in the earth's crust, six are among the eight whose lines are strongest in the solar spectrum, and one of the other two comes ninth in the solar list. Of the next eight metallic elements in the terrestrial list, seven are found among the second group of eight in the solar list, and the other one (Ni) is among the first eight. That is, fifteen of the sixteen leading metallic elements are common to the two lists, and there is a general similarity in their relative order in the two.

Beyond this point comparison becomes hardly practicable, as the terrestrial list is probably incomplete. Four of the next eight elements in Rowland's list are rare earths, for which there are as yet no sufficient analytical data. It is clear, however, that the elements whose lines are faint in the sun are, in general, present in but very small proportions in the earth's crust.

It is very remarkable that the correspondence of the two lists is so close, in view of the radical differences in the methods of investigation, and the great differences in the relative intensities of the lines in stellar spectra of different types. Even in the bright-line spectrum of the solar atmosphere, the similarity is by no means as pronounced.

Out of the first sixteen elements in either list, only one, barium, has an atomic weight exceeding 100, and but one other, strontium, one greater than 60. The significance of this fact has frequently been discussed by geologists or by astronomers.[5] In both cases it has been suggested that the heavier elements lie for the most part deep within the body, and out of reach; but Clarke gives good reasons for believing that, even in the earth's interior, the lighter elements are more abundant than the heavier. This suggests that the faintness or absence of the lines of the heavier metals in the solar spectrum may be due largely to the small proportions in which they occur, and some confirmation of this is found in the fact that, of the elements of atomic weight greater than 180, only lead, which is the most abundant in the earth's crust, appears at all in the sun. But the rarity of these elements cannot be the whole explanation of their absence from the solar spectrum, for although no lines of Os, Ir, or Pt occur in it, the stronger lines of the equally rare elements Ru, Rh, and Pd (whose atomic weights are about half as great) appear distinctly, though faintly.

The element which is most disproportionately conspicuous in the sun, in comparison with its terrestrial abundance, is cobalt. Nickel, too, is relatively high on the solar list. This may be partly explained by the great number of lines in the spectra of these elements, which gives them undue weight in a spectroscopic count. It is also worthy of notice that, if 25 per cent of meteoric iron were added to a sample of the earth's crust, and the composition of the resulting mixture considered, iron would occupy the first place among the metallic elements, nickel the eighth, and cobalt the eleventh, and the discordance with the solar list would disappear. Of the elements abundant in the earth, and relatively less conspicuous in the sun, silicon apparently approaches the typical non-metallic elements in its behavior, while aluminium has only four lines in the observable region, and is thus handicapped by the spectroscopic method of detection.

The principal differences in the order of the metallic elements in the two lists are therefore easily applicable, with one conspicuous exception. Potassium, which is one of the principal constituents of the earth's crust, and is fairly abundant in meteorites, shows as the merest trace, if at all, in the solar spectrum, although many strong lines, both of the principal and the subordinate series, lie in the observed region. Their absence, in spite of the presence of conspicuous lines of elements which are far less abundant in terrestrial materials, is remarkable, and would seem to demand some special explanation. It is of interest in this connection that potassium, alone among the more common elements, is slightly radio-active. If this indicates that its atoms are relatively unstable, they might break down under solar conditions; but this is a highly speculative consideration. The lines of the more strongly radio-active elements do not appear at all in the solar spectrum; but this may be accounted for by their extreme rarity (on earth, at least) and their high atomic weights. It should, however, be mentioned that lithium, which is next to potassium in abundance among the alkali metals, and occurs in sensible proportions in the earth's crust, but, so far as is known, is not radio-active, is also practically absent from the solar spectrum—though Adams[6] points out that a very faint line, greatly strengthened in sun-spots, at wave length 6708.08 may represent the strongest line in the lithium spectrum.

In spite of these exceptions, the agreement of the solar and terrestrial lists is such as to confirm very strongly Rowland's opinion that, if the earth's crust should be raised to the temperature of the sun's atmosphere, it would give a very similar absorption spectrum. A moderate mixture of meteoric material would make the similarity even closer.

* Reproduced from *Science*.

[1] *Astrophysical Journal*, 38, 407-495, and 39, 166-177, 1913-1914.

[2] As given by him in *Bulletin* 491 of the U. S. Geological Survey, pp. 27-33, with additional data from papers in the *Proceedings* of the American Philosophical Society, Vol. 51, p. 220, 1912, and the *Journal* of the Washington Academy of Sciences, Vol. 4, pp. 59-62, 1914.

[3] Quoted by Clarke on p. 39 of the work first cited.

[4] Publications of the Field Columbian Museum, Geological Series, Vol. 3, No. 5, p. 110.

[5] Compare Clarke, *op. cit.*, p. 33, and Abbot, "The Sun," pp. 92-94, 253-254.

The Great Meteor of February 9th, 1913*

By W. H. S. Monck

In the session of 1902 to 1903 I laid before the society in conjunction with the late Mr. Arthur Harvey, a catalogue of aerolites or meteors that had fallen to the earth in the solid state, and we both expressed our opinion that they came in recurring showers like ordinary meteors, though the richest meteor-showers seemed to be unproductive of aerolites, while much fainter ones were often accompanied by aerolites or fireballs. It was natural under the circumstances to refer to this catalogue in connection with the great meteor of February 9th, 1913, and I found there three actual stone falls on the 10th of February, one at Nanjemoy, Maryland, in 1825, another at Girgenti, Sicily, in 1853, and a third at Madrid, Spain, in 1896, besides which Mr. Harvey has in the supplemental list one at the Isle of Oleron, France, in 1875. There are, likewise, two falls on the 12th of February and two more on the 13th, one of the former pair being at Homestead, Iowa, in 1875, just two days after the fall at the Isle of Oleron, France.

Turning back to the *Monthly Notices* of the Royal Astronomical Society for the year 1865 to 1866, I find the late Mr. A. S. Herschel writing: "Detonating meteors were observed on the 10th of February, 1772, by Brydone; on the 11th of February, 1850, by the present Astronomer Royal, and on the 9th of February, 1865, by a friend of the writer at Bangalore, South India, all of which probably belonged to the zone of meteors circulating around the sun."

A list of eight American meteoric fireballs, an account of which was given by Prof. Daniel Kirkwood, in 1877, included one on February 8th, 1877, but as he had only one observation of this fireball he was unable to make his computations with regard to it. A brilliant day-light meteor was seen seventeen years later on February 8th, 1894. It was seen almost at noon by Dr. A. A. Rambaut, Astronomer Royal of Ireland, at Dunsink, near Dublin, and also by Mr. Wood, near Birmingham, and others. Its path was calculated by Dr. Rambaut and also by Mr. Wood, according to both of whom it was first seen at a height of about 80 miles over the Irish Sea and was lost sight of over Yorkshire after descending to less than one fourth of that height. This is not a bad collection and could no doubt have been added to if I had pursued my inquiries further; but I may give one more example. On February 11th, 1905, three bright meteors were doubly or more than doubly observed and paths determined for them by Mr. Denning, but they do not seem to have been as brilliant as most of those already referred to. There were, however, material differences between their radiants as computed by Mr. Denning. Two meteor-showers active on the same night is not unusual, but it would be unusual to find both of them rich in fireballs. Yet there is some reason for thinking so in the present instance. There is certainly no fireball shower in February previous to the 8th of that month, but the ending is much less definite than the beginning, and those on the 12th and 13th may, perhaps, have had a different source

* Reproduced from the *Journal* of the Royal Astronomical Society of Canada.

[6] *Astrophysical Journal*, Vol. 30, p. 92, 1909.

from those on the 8th, 9th, and 10th of February.

The multiplicity of the fireball of 9th of February, 1913, is not unusual, though with the ordinary small meteors it seems to be unknown. Mr. Harvey, in his article accompanying the catalogue already referred to, mentions that a swarm that fell at L'Aigle on the 26th of April, 1803, included 2,000 or 3,000 stones, that 700 or 800 were recovered from the fall of an aerolite in Iowa, U. S., on the 2d of May, 1890, and 100,000 (there seems to be some exaggeration here) from one at Pultusk on January 30th, 1868. There was, however, a very conspicuous example of the same kind of multiplicity that the great meteor of February 9th, 1913, exhibited in a famous English meteorite of 18th of August, 1783. The *Annual Register* for that year contains a full account of it as seen at Greenwich Observatory, and the resemblance will at once strike the reader. The Madrid meteorite, I may remark, left a train which was long visible as a cloud. It was a day-light meteor seen in the sunshine at about 9 hours 30 minutes A. M.

Reverting to the multiplicity of some of these meteorites, a question arises as to how it is to be explained. Did all the company of meteors originally form a single body which afterward became split up and divided, or had they always a separate existence through traveling together? Their condition is quite distinct from that of what is called a meteor-swarm. In the latter case, though the meteors succeed each other at very short intervals of time, when we consider the speed at which they are traveling, the distance between any pair of them evidently amounts to several miles. If a number of them fell to the earth simultaneously they would be scattered over several square miles of the earth's surface. But when these multiple meteors fall we have hundreds or thousands of them scattered over a very small district. This could hardly occur if they were originally a solid body which was afterward broken up by one or more explosions. The fragments would not keep in such close company at any considerable distance from the place where the explosion occurred. Perhaps some light may be thrown on the subject by a theory of my late friend Sir Robert Ball, though I do not know whether he modified it before his death. These aerolites, or meteorites—stones that actually fell—were, he thought, projected from terrestrial volcanoes at a time when they were more active than at present. If projected with sufficient velocity they would commence revolving in independent orbits, instead of falling back to the earth as they do when projected at present; and while traveling in these orbits they would be liable to encounter the earth and thus return to us after a long interval. Here it is evident that a number of stones projected from the same volcano at the same time might travel in close company for a considerable distance. And I know of no reason why other celestial bodies might not have something analogous to our volcanoes still active and capable of ejecting companies of small bodies. There seems, indeed, to be reasons to believe that the sun is constantly ejecting matter, though not perhaps in the solid or liquid form. An explosion or some kind of collision at the outset would probably prevent the bodies from keeping close together during a course of any considerable length, but an action of a volcanic kind might perhaps remove this difficulty.

Another puzzle is this: These detonating meteors are sometimes of dazzling brilliancy and appear at great heights in the atmosphere, moving with great velocity. Yet the stones that fall are often but slightly heated and are sometimes seen to fall very slowly and almost perpendicularly. How can both of these characters be ascribed to the same meteors? Or are these two distinct species of fireballs, one of which only fall to the earth on rare occasions?

Let us then consider the conditions under which a falling meteor will reach the earth in the solid form. What usually happens when it enters the atmosphere is this: Entering with a high velocity, the air resists it and diminishes its speed, the motion thus lost being converted into heat, which raises the temperature of the meteor and renders it first red-hot and then white-hot, after which it melts and finally evaporates when the vapor of the meteor gets mixed with the air, and we cease to be able to trace it. Except the melting-point (or rather the evaporation point) of the meteor, the only elements involved here are its size and its velocity, but when it has penetrated so far that a combination with some of the elements of the air may take place, this possibility may also require consideration. But, in the first place, the greater the velocity the less chance there is of the meteor remaining solid until it reaches the earth, because the greater the velocity the greater is the amount of heat developed by destroying its motion. And this is probably the reason why no meteor belonging to the great Leonid or Perseid streams seems to have fallen to the earth. The meteors are traveling with a high velocity and they are also, as a rule, very small—which brings us to the next point, viz., a large meteor is more likely to reach the earth than a small one. Perhaps I should rather say that a part of it is more likely to reach the earth; for part may be vaporized or melted, while another part remains solid until it encounters the earth. The center of a large meteorite might still remain cool after the parts near the surface had been fused and evaporated. Large size and slowness of motion are thus most favorable for the production of aerolites, but unusual size on the one hand or unusual slowness on the other might suffice where the other element differed little from the average.

These large fireballs, however, are usually explosive or detonating, and it is usually after an explosion that an aerolite is seen to fall and is picked up. What effect has such an explosion on the meteorite which is thus separated into parts? Much evidently depends on the force of the explosion, regarding which little is known, but plainly a number of parts are driven out of their former course into a new one resulting from the explosion; and assuming that this new force is not insignificant when compared with the meteor's velocity at the moment of the explosion, the previous velocity of some fragments may be almost annihilated, while that of others is increased. The explosion may thus cause some parts of a detonating meteor to fall to the earth while the main body escapes into space to visit us again on some future occasion, or perhaps is dissipated in the air. This seems to have occurred in a few instances, but they are hardly sufficiently ascertained to be relied on. One of these is the great meteorite of 18th of August, 1783, referred to by Mr. Harvey in the *Catalogue*.

There is evidently a good deal still to be discovered with regard to these meteorites, or aerolites, and their connection with the earth, and it is much easier to ask questions than even to suggest answers to them. I hope, however, that the entire subject will receive more attention from astronomers than it has usually received of late years, and that none of these elements, which I may call observation, calculation, and speculation, will be wanting. The progress in this department during the last quarter of a century has been very slow. I hope some of our leading astronomers will devote their attention to the subject and ascertain the problems to be solved and the direction in which we should look for a solution of them.

Introduction to the New Statistics with Special Reference to the Needs of Biologists

By J. Arthur Harris

THE number of guides to modern statistical methods consequent upon the realization that mathematical analysis is necessary for the full interpretation of series of observations, is now so large that it may be helpful to the beginner to point out some of their chief features.

While Francis Galton's "Hereditary Genius" of 1869 shows the influence of the work of Quetelet, his "Natural Inheritance" of 1889 is probably the first book published in which the modern student can find any consistent comprehensive explanation of the statistical methods as applied to biological problems. While this classic should be familiar to every statistician, it is not suitable as a guide to the beginner, for the formulæ there described have been replaced by those better suited to the practical routine of calculation.

Among the earlier treatises on the new statistics—speaking now of introductions and guides, not of original work—may be mentioned those of Duncker[1] and Davenport[2], written from the standpoint of methods, and the volume of Vernon[3] prepared more as a summary of progress in the study of variation, but giving some elementary explanations of methods.

Of more recent works those of the greatest value have appeared in the English language. It would have been too much to expect that the influence of the newer work would extend as far as Madrid and affect the "Tratado Elemental de Estadistica" of Menguez y Vicente (1907), but something better might have been expected of France and Germany. How backward they are can be seen from such essays as Zizek's "Soziologie und Statistik," München und Leipzig, 1911, or those in the "Festschrift" for Georg von Mayr, "Die Statistik in Deutschland nach ihrem heutigen Stand," München und Berlin, 1911. Such works as F. Faure's "Elements de Statistique" and Maciejewski's "Nouveau Fondements de la Theorie de la Statistique" (1911) have, in spite of their attractive titles, no practical value to the biologist—or, as far as the present reviewer can see, to anyone else.

Nor can anything be said in favor of Al. Kauffmann's "Theorie und Methoden der Statistik," just published (Tübingen, 1913).

Forscher's recent book[4] seems to be a serious attempt, apparently done in almost complete ignorance or with all but a total disregard of the fundamental calculus of the English school, to obtain a better theoretical (mathematical) basis for statistical formulæ. Of the soundness of the mathematical work, I am not able to judge; nor does it particularly concern us here, for practically—that is, as a tool for the man grappling with practical statistical problems—the work has little immediate value.

Turn now to introductory works which may be of value to the beginner.

Many biologists and others are very deeply indebted to the sections on Heredity, Selection and Evolution in the second edition of Pearson's "Grammar of Science" for their first knowledge of the new methods. The second edition is out of print, but a third is being issued.

"The Primer of Statistics" (London, A. & C. Black, 1909) prepared by the Eldertons at the suggestion of Sir Francis Galton, is for the general public rather than for one who hopes to prepare for investigation. King's little book[6] although containing something of the newer methods, is for the social rather than for the biological student, and is far too elementary for those who wish to do research work. Elderton's book[6] not only embodies the actuaries' viewpoint, but presupposes the actuaries' training. Thus as a *first* book it is quite beyond the depth of the average biologist, but if he is working seriously in statistics it is most helpful on his table.

That Eugene Davenport's book[7] on breeding—with all its points concerning which the doctors in mathematics and the doctors in biology will disagree—is a pretty good introduction for a certain class of readers, is perhaps sufficiently established by the influence which it has evidently exerted in our agricultural institutions. One recognizes the scissors and paste nature of the volume, but this characteristic it shares with practically all the other introductions to statistical methods; the compilation is only a little more obvious and the compiler distinctly more honest in the acknowledgment of original sources than is sometimes the case.

Thorndike[8] several years ago prepared an introduction for the use of psychologists which has recently (1913) been issued in a much-amplified second edition. The work is more elementary and far more verbose than the book by Brown.[9] For this reason, Thorndike's text is better as an introductory work for most American students, while Brown's more technical and more comprehensive book is indispensable to those who care to do really serious research. In this connection, the work of Urban[10] may also be mentioned.

The most comprehensive text on modern statistics—an introduction to statistical theory rather than a guide to the application of statistical analysis in any particular field—is that of Yule,[11] who has brought to his task the training of an assistant in Karl Pearson's laboratory. To all those who must use statistical formulæ without being able to read with ease the fundamental papers—and this comprises all but a handful of the workers—Yule's book is indispensable. The simpler statistical processes are all treated with care and clearness, and with a terseness refreshing after the verbiage of works written from the biological viewpoint. One must commend the careful system of cross reference, which should greatly facilitate the use of the book, and the very complete and annotated bibliography, which should inspire the student to study original sources. The student, moreover, should remember that even Mr. Yule's book does not render this unnecessary, for in the text some subjects of great importance are not treated at all. For example, one misses a discussion of Pearson's various types of frequency curves which have been used with such success for the past several years in describing a great variety of phenomena. The classical fourfold correlation method is also omitted. The most flagrant fault of the book is the putting forward of certain meas-

[1] Duncker, G., "Die Methode der Variations-statistik," *Archiv. f. Entwicklungsmechanik d. Organismen*, Vol. viii., pp. 112–183. 1899.

[2] Davenport, C. B., "Statistical Methods with Special Reference to Biological Variation," New York, 1899, second ed., 1909.

[3] Vernon, H. M., "Variation in Animals and Plants," New York, 1903.

[4] Forscher, H., "Die Statische Methode als Selbstandige Wissenschaft. Eine Einführung in deren Fundamente und Grundzüge," Leipzig, 1913.

[6] King, W. I., "Elements of Statistical Method," New York, Macmillan, 1912. *Cf. Science*, N. S., Vol. 36, p. 519, 1912.

[6] Elderton, W. P., "Frequency Curves and Correlation," London, C. & E. Layton, 1906.

[7] Davenport, E., "Principles of Breeding," with an appendix on Statistical Methods by H. L. Rietz, 1907.

[8] Thorndike, E. L., "An Introduction to the Theory of Mental and Social Measurements," New York, 1904.

[9] Brown, W., "The Essentials of Mental Measurements," Cambridge University Press, 1911.

[10] Urban, F. M., "The Application of Statistical Methods to the Problems of Psycho-Physics," Philadelphia, 1908.

[11] Yule, G. U., "An Introduction to the Theory of Statistics," London, Chas. Griffen & Co., 1911, second edition later.

ures of association and correlation, which are worthless,[12] but which, because of their simplicity, are likely to be widely used by those who prefer ease of calculation to correctness of result.

The guides which are available, the beginner must use; but he should know that there is not only no royal road, but as yet no Baedeker, to statistical analysis. Here, as is wont to be the case with text-books, the guides have for the most part been written by men who have not distinguished themselves by exploration into the territory through which they now propose to lead others. The real student will, therefore, be vigilantly skeptical, and will go as far as he is able to the original sources to read and weigh for himself.

Taking the books mentioned in this review as a class, the greatest criticism that can be made is not that there are blunders in statement and misprints in formulæ, but that throughout there is an incautious attitude toward the real difficulties which the student is to encounter, or even a positive assurance that dangers are only apparent. Nothing could be farther from the truth, for in higher statistics innumerable pitfalls surround the investigator. Serious harm has been done by telling the beginner that he need not understand the formulæ to use them. Neither is it necessary for a chemist to understand his reagents! To be sure, most of us have of necessity to work with but little knowledge of the mathematics which lie back of the formulæ, but it is the obvious duty of the student who proposes to use these newer tools of research to learn all he can concerning the assumptions on which the formulæ rest in order to apply them with intelligence.

Finally, the beginner must realize that it is as impossible to gain a working knowledge of statistical methods from a text-book without experience in the routine of measurement, computation and interpretation as to acquire proficiency as an organic chemist outside the laboratory. It takes years of hard work to make a proficient biometrician—although some have to their own satisfaction qualified for the writing of texts much more easily.—*Science.*

[12] See Heron, *Biometrika*, Vol. 8, pp. 109–122, 1911; K. Pearson and D. Heron, *Biometrika*, Vol. 9, pp. 159–315, 1913.

The Influence of Antivivisection on Character—II*

Misrepresentation, Falsehood and Passion the Characteristics of Antivivisection Propaganda

By W. W. Keen, M.D., Philadelphia

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Two men are especially obnoxious to the antivivisectionist: Pasteur, whose demonstration of the cause of that form of infection known as puerperal or childbed fever alone would have made his name immortal; and Lister, whose application and extension of the principles laid down by Pasteur have revolutionized all modern surgery.

I need not argue the case for Pasteur, Lister and modern antiseptic surgery. Excepting the antivivisectionists, every intelligent man and woman the world over *knows* that modern surgery has been made safe by their researches. Let me give a single instance.

In the charming "Life of Pasteur" by René Vallery-Radot, it is stated[13] that, hoping to overcome the almost invariably fatal results of ovariotomy in the hospitals, the authorities of Paris "hired an isolated house in the Avenue de Meudon, a salubrious spot near Paris. In 1863 ten women in succession were sent to that house. The neighbors watched those ten patients entering the house, and a short time afterward their ten coffins being taken away!" When I was the assistant to the late Dr. Washington L. Atlee in the late 60's, two patients out of three on whom he, the foremost ovariotomist in America, operated, died.

To-day, thanks to Pasteur and Lister and modern surgery, based on experiment on animals more than on any other foundation, not more than two or three in a hundred die after ovariotomy. Yet, if the antivivisectionists had prevailed, the horrible mortality of the earlier days and even the tragedy of the ten women and the ten coffins would still exist. Is not this cruelty?

Let me take another illustration of a similar cruelty, a form especially interesting to women. Prof. J. Whitridge Williams,[13] professor of obstetrics in the Johns Hopkins University, states the following facts: In 1866, Lefort showed that in 888,312 obstetric cases in the hospitals of France up to 1864, 30,394 women had died of puerperal fever; that is to say, 3.5 per cent, or about every twenty-seventh mother. From 1860 to 1864, the mortality in the Maternité of Paris had risen nearly fourfold, to 12.4 per cent. In December, 1864, it rose to 57 per cent; that is to say, *more than one-half* of the women who bore children in that hospital in that month died of childbed fever! In Prussia alone, in the 60 years from 1815 to 1875, Boehr showed that 363,624 women had died of the same fever and estimated that every thirtieth prospective mother was doomed to death from that cause. In the United States, Hodge, of Philadelphia, showed that in the Pennsylvania Hospital from 1803 to 1833 there had been a mortality of 5.6 per cent; i. e., every eighteenth mother was doomed. Lusk reported an epidemic in 1872 with 18 per cent; that is, almost every fifth mother perished from the same fever!

The result of Pasteur's researches and the practical application of Lister's antiseptic method to obstetrics as well as to surgery have borne the most astounding and gratifying fruit. For instance, in 1909, Markoe reported in the New York Lying-In Hospital in 60,000 births a maternal mortality of only 0.34 per cent, and Pinard in 1909 in 45,633 births recorded a mortality of only 0.15 per cent, while in 1907 Mermann had been able to report a mortality of only 0.08 per cent in 8,700 patients! In other words, these reports show in round numbers that, taking in the two extremes, the deaths from childbed fever fell from the extraordinary rate of 57 in 100 mothers, or the former usual rate of 5 or 6 in every 100 mothers, to 1 mother in 1,250.

If for 50 years past the antivivisectionists had had their way, all these marvelous results in obstetrics would have been prevented and women would still be dying by the hundred and the thousand from puerperal fever—an entirely preventable disease. Would it not have been the height of cruelty to stop these experiments? But according to the *Journal of Zoophily* such wonderful life-saving experiments should be prohibited, "*no matter how great the anticipated benefit.*"

In surgery, erysipelas, blood-poisoning, lockjaw, hospital gangrene, etc., would still be killing our patients right and left; weeks of suffering, to say nothing of danger, would confront every patient operated on; the modern surgery of the head, of every organ in the abdomen and pelvis, of tumors and of cancer, amputations and many other operations, instead of being almost painless and so safe as they are to-day, would be the cause of prolonged illness, pain and death; in fact, most of them would be deemed entirely impossible of performance—they *were* impossible before Pasteur and Lister—and animals themselves would still be suffering as of old from animal maladies whose causes are now known and whose ravages have been enormously diminished.

Call you not the desire to arrest such experiments cruelty to man and animals alike?

In a speech in the House of Commons, April 4th, 1883, Sir Lyon Playfair, the Deputy Speaker, said:

"For myself, though formerly a professor of chemistry in the greatest medical school of this country (Edinburgh), I am responsible only for the death of two rabbits by poison, and I ask the attention of the House to the case as a strong justification for experiments on animals; and yet I should have been treated as a criminal under the present act (the British vivisection law) had it then existed.

"Sir James Simpson, who introduced chloroform, . . . was then alive and in constant quest of new anesthetics. He came to my laboratory one day to see if I had any new substances likely to suit his purpose. I showed him a liquid which had just been discovered by one of my assistants, and Sir James, who was bold to rashness in experimenting on himself, desired immediately to inhale it in my private room. I refused to give him any of the liquid unless it was first tried on rabbits. Two rabbits were accordingly made to inhale it; they quickly passed into anesthesia and apparently as quickly recovered, but from an after-action of the poison they both died a few hours afterward. Now was this not a justifiable experiment on animals? Was not the sacrifice of two rabbits worth saving the life of the most distinguished physician of his time?"

As this experiment was not for the good of the two rabbits, but in fact killed them, in the eye of present-day antivivisectionists it would be wrong, and, if they had their way, illegal and punishable, and Simpson would have lost his life. Would not this be cruelty?

Moreover, these very same people who so strenuously oppose vivisection, in their own households and without the slightest pity will kill rats and mice by turning them over to the tender mercies of cats, by drowning them, by strangling them in traps, by poisoning them with strychnin or phosphorus, or by any other means of "torture"; but they hold up their hands in holy horror when any proposal is made to terminate the lives of other rats and mice almost always without pain and with immense benefit to humanity. They are cruel and callous to human suffering so long as dogs and cats, mice and guinea-pigs escape! And yet, as I have shown, only 26 animals in 1,000 can possibly ever suffer at all!

That sentiment rather than principle is at the bottom of the antivivisection crusade is shown by what I in common with many others believe to be true, that if experimental research could be carried on in other animals without using dogs and cats there would scarcely have been such a thing as an antivivisection movement.

III. DIMINISHING OF REVERENCE FOR ACCURACY.

The third way in which the influence of antivivisection injures character is by diminishing the reverence for accuracy. In 1901, I gave many instances[14] of the misstatements of the antivivisectionists. These misstatements were contained in two anonymous pamphlets, and I have two more similar publications which are also anonymous. I have before me also three publications purporting to be replies to that publication of mine, all again anonymous. Is a foe who attacks from ambush worthy of the respect and confidence of the public?

These misstatements, so far as I know, are still distributed in leaflets and pamphlets without correction nearly 11 years after their incorrectness was shown. In fact, several of them reappear uncorrected in the *Journal of Zoophily* for July, 1911.

Let me give a few new instances.

The most prominent antivivisectionist in England is Mr. Stephen Coleridge. On page 183 (April to July, 1907) in the minutes of his evidence before the Royal Commission on Vivisection, I find the following:

Question 10952: We may have inspection, but still we may ask a person of character when he saw the experiment what his opinion of it was. Will you not accept that?

Answer: Certainly not, because I think that all these experimenters have the greatest contempt for the act of Parliament. They would deny a breach of this act just as I should deny a breach of the motor car act. I drive a motor car and *when I go beyond the speed limit* and the policeman asks me I say, '*No, I am not going beyond the speed limit*'[15] (italics mine). Nothing would keep me from going beyond the speed limit except the presence of a policeman in the car; and nothing will keep the experimenter within the four corners of the act except an inspector in the laboratory.

Question 10953: Surely, if you were asked about the speed limit and gave your word that you had not exceeded it, you would not expect to be disbelieved?

Answer: No, I did not say so. I said last year that of course I did, and I exceed it every time.

Question 10954: *You are apparently not very ethical about motor cars* (italics mine). If you apply your principles as regards motoring to the physiologists, you have very little to say against them?

Answer: What I have to say is that they regard the vivisection act of 1876 with the same contempt that I regard the motor car act as regard the speed limit.

In quoting also a letter from the Home Office, Mr. Coleridge admits mutilating it, for in reply to Question 11015, he says, "I seem to have left out the important item of it." See also Questions 10301, 11011, 11024 and 19967 to 19973.

Comment on Mr. Coleridge's testimony is superfluous.

Again in the "Black Art of Vivisection," Mr. Coleridge states, "The Pasteur institutes in Paris and elsewhere have entirely failed to prevent people dying of hydrophobia." Yet the fact is that formerly from 12 to 14 per cent of persons bitten developed the disease and every

[13] Vallery-Radot: Life of Pasteur, II, 16.

[13] Williams, J. Whitridge: Obstetrics and Animal Experimentation, *Journal American Medical Association*, April 22nd, 1911, p. 1159, and this series of pamphlets No. XVIII.

[14] Keen, W. W.: Misstatements on Antivivisection, *Journal American Medical Association*, February 23rd, 1901, p. 500.

[15] In a letter referring to this address (*Boston Medical and Surgical Journal*, July 11th, 1912, p. 71), Mr. Coleridge says that I seem "quite shocked that he should admit that he constantly breaks the law and exceeds the speed limit of 20 miles an hour in his motor car," and that "a quarter of a million motorists" do the same. If the reader will again peruse Mr. Coleridge's testimony, as quoted in the text, he will find that there are two admissions: (1) that he constantly breaks the law, i. e., the "statute law" of England as to the speed limit; and (2) that when he goes beyond the speed limit, and the policeman asks him, he says, "*No*, I am *not* going beyond the speed limit." The last statement is what gives special point to the quotation from his evidence, but in his letter he omits any reference to this more important admission.

one of them died, whereas the result of the Pasteur treatment in 55,000 cases has diminished the mortality to 0.77 per cent of those bitten.

I cite another English instance. In "The Nine Circles"[16] is published a reply to a letter by Sir Victor (then Mr.) Horsley, published in the London *Times*, October 25th, 1892, a copy of which I have before me. The book, as the London *Times* points out in an editorial, was

"Compiled under his (Dr. Berdoe's) direction. He was entrusted with the task of reading the proofs, and was supposed to safeguard the accuracy of 'the compiler.' He now admits that he overlooked in Miss Cobbe's preface a passage in which she 'was careful to say, . . . so far as it has been possible, the use or absence of anesthetics has been noticed in regard to all the experimenters cited in this book.' Mr. Horsley in the appendix to his letter, which we publish this morning, shows by reference to some twenty cases cited in 'The Nine Circles' how entirely inconsistent with the truth this guarantee is, and Dr. Berdoe's reluctant acknowledgment completes the proof."

A still more remarkable letter appears in the same number of the *Times* from Prof. C. S. Sherrington, of Liverpool. He says:

"I find in the book, 'The Nine Circles,' three instances in which I am by name and deed held up to public abhorrence. From each of the three statements made about me the employment of anesthesia in my experiments is studiously omitted, although expressly mentioned in each of the published papers on which these statements are professed to rest. In two out of three statements I am accredited with inflicting on living animals, and without the employment of anesthetics, a dissection and procedure that I *pursued only on animals which were dead*."

Accordingly the society withdrew the book from the market, but later published a revised second edition.

In his reply to Prof. Horsley's letter calling attention to the misstatements in the first edition, the excuses that Dr. Berdoe gives in this second edition are very extraordinary. Among them, for example, one is "the sentence about testing the sight after recovery from the anesthetic was overlooked."

Another excuse is "this was taken at second hand from another report where the question of pain was not under discussion." In a third, he says: "We have not always access to 'original papers' and can only rely on such reports and extracts as are given in the medical and other journals."

I ask whether it is fair, square dealing to base grave charges of cruelty on sentences "overlooked" and on "second-hand" misinformation?

But Miss Cobbe was by no means satisfied with misrepresenting English medical men. In the pamphlet "Vivisection in America," I find on page 9 a letter by a Boston lawyer in which he says of American experiments: "In other words, animals are dissected alive *usually without the use of anesthetics*, for the supposed (but illusory) gain to science." (Italics mine.) I have already given a table showing that only 26 animals out of 1,000 could by any possibility have suffered any pain, and that even these were anesthetized. Is it correct, then, to say that animals are "dissected alive usually without anesthetics"?

Near the top of page 45, Miss Cobbe's pamphlet reads as follows:

"Dr. Ott, in the *Journal of Physiology*, Vol. II, p. 42, describes a number of experiments on a number of cats *not etherized* (italics my own), for the purpose of making observations on the physiology of the spinal cord."

I find that on reading the original paper there were four series of experiments:

In the first series, there were 20 experiments. In the first experiment the animal was killed before the experiment began. In 11 other instances, it is expressly stated in each experiment that the animals *were* etherized. Dr. Ott informs me that the other 8 were also etherized and that he invariably etherizes the animal.

In the second series there were 8 experiments. On page 52 of the *Journal of Physiology*, it is stated that the animals *were* etherized.

The third series consisted of 10 experiments, and on page 54 it is expressly stated that the animals *were* etherized.

The fourth series consisted of 10 experiments, and, again, on page 60, it is stated that the animals *were* etherized. We see, therefore, that Miss Cobbe's statement "not etherized" is untrue, for of 48 animals, one was killed; in 39, it is expressly stated that they were etherized; leaving only 8 out of 40 as to the etherization of which nothing is said, though it was done.

On pages 45 to 48, I find a series of experiments on the surgery of the pancreas by the late Dr. Senn, of Chicago. This was in July, 1886, at a time when the surgery of the pancreas was just beginning. Two pages and a half of Miss Cobbe's pamphlet are devoted to describing in detail experiments which, as no mention is made in her pamphlet of ether, one would certainly suppose were done without ether and would certainly be very painful. On looking at page 142 of the original paper, I find that it is expressly stated that the animals *were* etherized.

In a series of experiments by Halsted, under experiment No. 6, p. 51, Miss Cobbe's pamphlet says, "Died under the operation, which was carried on for two hours on a young, small brindle dog," which would imply two hours of "agony." The original expressly states the fact that this dog died *from the effects of the ether.*

Another illustration of the way in which sentences are detached from their context and made to mean quite different things and repeatedly published years after the falsity of the statement has been demonstrated is shown by the constant inclusion of Sir Frederick Treves among the opponents of vivisection. He stated of one single investigation that operations on the intestines of dogs in his opinion—other surgeons do not hold the same opinion—were useless as a means of fitting the surgeon for operations on the human bowel. Ever since this utterance[17] Sir Frederick Treves has been constantly quoted in the manner mentioned, yet in a letter to the London *Times* of April 18th, 1902, he says:

"The fallacy of vivisection can hardly be said to be established by the failure of a series of operations dealing with one small branch of practical surgery. No one is more keenly aware than I am of the great benefits conferred on suffering humanity by certain researches carried out by means of vivisection."

This was noticed editorially in the *British Medical Journal* of April 26th, 1902. So late as 1909, in the May number of the *Journal of Zoophily*, the editor-in-chief, Mrs. Caroline Earle White, reprints from the *North American* of April 12th, 1909, her signed letter, and implies that Sir Frederick Treves is an opponent of vivisection, 7 years after this correction had appeared. In the number of the same journal for July, 1909, the associate editor of the journal prints a letter of denial from Sir Frederick Treves, and yet so late as the number for March, 1911, p. 177, the same old quotation from Sir Frederick Treves is published in the same journal which 22 months before had printed his own letter of denial.[18, 19].

At the annual meeting of the Research Defense Society, Sir Frederick Treves, in referring to the great progress made in the science of medicine, said: "This progress has, in the main, been accomplished by experiments on animals." Ought not his name hereafter to be omitted from the list of the opponents of vivisection?

A postal card issued by the American Antivivisection Society in Philadelphia (there are several others of the same sort) presents a picture of a large dog with his mouth gagged wide open and his paws tied "without anesthetic." The object of the gag, of course, is to prevent the animal from biting before and while it is being etherized. It is absurd to state that this produces any pain, but a guide at the traveling antivivisection exhibition explained to two of my friends that it was used to *break the jaws of the dogs!* and that this was done "without anesthetics." But in nearly all our surgical operations within the mouth, on the tonsils, cleft palate, the tongue, etc., we employ gags of various kinds to keep the mouth wide open. To show how little annoyance this causes, here is a picture (Fig. 2) of a little girl, 4 years old, my own granddaughter, with a mouth-gag which I have used many times over with children and adults in operations about the mouth. This particular photograph, it will be observed, was taken also "without an anesthetic." It was not necessary to tie her hands and feet as is done with dogs, for the child regarded the whole proceeding of photographing her with her mouth wide open as a "lark," and sat as still as a mouse. Is it necessary to add that her jaw was not broken?

Fig. 2.—Such mouth-gags as this are used both on human beings and on animals, and are quite painless.

Miss Britton, in her $300 antivivisection prize essay[20] vividly describes an operation (removal of the breasts of a nursing mother dog) which was *never done at all.* This fictitious operation is described in "The Nine Circles"[21]; again it appears in Dr. Albert Leffingwell's essay, "Is Science Advanced by Deceit?" published in 1900. In 1901, Prof. Bowditch called Dr. Leffingwell's attention to the fact that no such operation was ever done. In Dr. Leffingwell's collected essays entitled "The Vivisection Question," on page 169 of the second revised edition (1907), there is, in a footnote, a correction admitting that no such operation was ever done, but on page 67 of the same edition, a description of this same operation still appears uncorrected, 6 years after Bowditch's letter had been received and the misstatement acknowledged.

In the exhibit of the American Antivivisection Society in Philadelphia, in November, 1911, a portrait of a dog was shown with a large placard stating correctly that the dog had been stolen from its owner and sold to the University of Pennsylvania for experiment. It omitted to state the further fact, which is perfectly well known, that the dog was kept for identification under Rule 1 (page 12), was claimed, identified and turned over to its owner and *not* used for experiment. Such a placard stating half the truth but not the whole truth inevitably leads the public to draw a false conclusion.

When a witness is called, it is not allowable for the party calling him to accept a part of his testimony and refuse to accept the rest, yet this is precisely what the opponents of research do. They always cite, for example, the late Prof. Bigelow, printing his earlier utterances based on the suffering he saw at Alfort in the preanesthetic days, but they carefully omit the following later expression of opinion:[22]

"The dissection of an animal in a state of insensibility is no more to be criticised than is the abrupt killing of it, to which no one objects. The confounding of a painful vivisection and an experiment which does not cause pain—either because the animal is under ether, or because the experiment itself is painless, like those pertaining to the action of most drugs, or because it is a trivial one and gives little suffering—has done great damage to the cause of humanity, and has placed the opponent of vivisection at a great disadvantage. . . . A painless experiment on an animal is unobjectionable."

So, too, when the statements of Horsley, Ott, Crile and others that the animals were anesthetized and suffered no pain are shown to antivivisectionists, they reply, "We do not believe it, for the only testimony to this insensibility to pain is that of the vivisectors themselves." They greedily accept as true all their other statements as to the operations they did, etc., down to the minutest details, but they refuse to accept those as to anesthesia. No court of law would sanction such a course.

In reviewing the preceding misstatements and those quoted in my former paper[16] I have been compelled to conclude that it is not safe to accept any statement which appears in antivivisection literature as true, or any quotation or translation as correct, until I have compared them with the originals and verified their accuracy for myself. Not seldom this is impossible, as no reference to the volume, month, day, or sometimes even the year of publication is given.

Lest the reader think this too severe a statement, I will refer to only one instance in the anonymous pamphlet, "Human Vivisection," in addition to others already shown to be grossly inaccurate.

On page 9 in the account of Sanarelli's five experiments in the endeavor to inoculate yellow fever, the phrase "the final collapse" appears as an alleged translation of the original Italian. The word "final" does not occur in the original. Moreover, the collapse was not "final," for every one of the five patients recovered, yet the pamphlet says that "some if not all of them died." The phrases "scientific murder" and "scientific assassination" are also freely used. Even the cover and the title-page of this pamphlet have as a motto: "Is scientific murder a pardonable crime?" As not a single patient died, were they really "murdered" or "assassinated"?

CONCLUSIONS.

In 30 years, the 16 (British) antivivisection societies have received more than £100,000 ($500,000) according to Mr. Stephen Coleridge's testimony before the Royal Commission on Vivisection (Questions 10256 to 10260). The American societies have had many bequests given

[16] Second edition, pp. 23–28.

[17] Treves, Sir Frederick: *Lancet*, London, November 5th, 1908.

[18] Just as I had corrected the proof of this paper, April 29th, 1912, I received through the mail from Mrs. Caroline Earle White a reprint of her letter of April 12th, 1909, with the same misleading quotation, thirty-three months after Sir Frederick Treves' letter of denial had been printed in her own journal.

[19] Treves, Sir Frederick: *British Medical Journal*, July 8th, 1911, p. 82.

[20] "Our Dumb Animals," January, 1910.

[21] Second edition, p. 28.

[22] Bigelow, Henry J.: Anesthesia: Addresses and Other Papers Boston, 1900, p. 371.

to them, and in the aggregate must have also spent a large sum of money.

On the other side, the friends of research and progress have had little money, have had to stop research and waste a deal of precious time in defending their beneficent researches from the attacks of the antivivisectionists; the rest of the time they have quietly gone about their business, adding to the sum of our knowledge and forging new and more efficient weapons against disease and death.

What, then, is the net result? What have the friends of research accomplished, and what achievements can the foes of research show? Let me put it in a contrasted tabular form and confine it to what has occurred during my own professional life.

THE ACHIEVEMENTS OF THE FRIENDS OF RESEARCH.

1. They have discovered and developed the antiseptic method and so have made possible all the wonderful results of modern surgery.

2. They have made possible practically all modern abdominal surgery, including operations on the stomach, intestines, appendix, liver, gall-stones, pancreas, spleen, kidneys, etc.

3. They have made possible all the modern surgery of the brain.

4. They have recently made possible a new surgery of the chest, including the surgery of the heart, lungs, aorta, esophagus, etc.

5. They have almost entirely abolished lockjaw after operations and even after accidents.

6. They have reduced the death-rate after compound fractures from 2 out of 3, i. e., 66 in 100, to less than 1 in 100.

7. They have reduced the death-rate of ovariotomy from 2 out of 3, or 66 in 100, to 2 or 3 out of 100.

8. They have made the death-rate after operations like hernia, amputation of the breast and of most tumors a negligible factor.

9. They have abolished yellow fever—a wonderful triumph.[29]

10. They have enormously diminished the ravages of the deadly malaria, and its abolition is only a matter of time.

11. They have reduced the death-rate of hydrophobia from 12 to 14 per cent of persons bitten to 0.77 per cent.

12. They have devised a method of direct transfusion of blood which has already saved very many lives.

13. They have cut down the death-rate in diphtheria all over the civilized world. In 19 European and American cities it has fallen from 79.9 deaths per 100,000 of population in 1894, when the antitoxin treatment was begun, to 19 deaths per 100,000 in 1905—less than one quarter of its death-rate before the introduction of the antitoxin.

14. They have reduced the mortality of cerebrospinal meningitis from 75 or even 90 odd per cent to 20 per cent and less.

15. They have made operating for goiter almost perfectly safe.

16. They have assisted in cutting down the death-rate of tuberculosis by from 30 to 50 per cent, for Koch's discovery of the tubercle bacillus is the cornerstone of all our modern sanitary achievements.

17. In the British army and navy they have abolished Malta fever, which in 1905, before their researches, attacked nearly 1,300 soldiers and sailors. In 1907, there were in the army only 11 cases; in 1908, 5 cases; in 1909, 1 case.

18. They have almost abolished childbed fever, the chief former peril of maternity, and have reduced its mortality from 5 or 10 up even to 57 in every 100 mothers to 1 in 1,250 mothers.

19. They have very recently discovered a remedy which bids fair to protect innocent wives and unborn children, besides many others in the community at large, from the horrible curse of syphilis.

20. They have discovered a vaccine against typhoid fever, which among soldiers in camps has totally abolished typhoid fever, as Ex-president Taft has so convincingly stated.[30] The improved sanitation which has helped to do this is itself largely the result of bacteriologic experimentation.

21. They are gradually nearing the discovery of the cause, and then we hope of the cure, of those dreadful scourges of humanity, cancer, infantile paralysis and other children's diseases.

Who that loves his fellow creatures would dare to stay the hands of the men who may lift the curse of infantile paralysis, scarlet fever and measles from our children and of cancer from the whole race? If there be such cruel creatures, enemies of our children and of humanity, let them stand up and be counted.

22. As Sir Frederick Treves has stated, it has been by experiments on animals that our knowledge of the pathology, methods of transmission and the means of treatment of the fatal "sleeping-sickness" of Africa has been obtained and is being increased.

23. They have enormously benefited animals by discovering the causes and in many cases the means of preventing tuberculosis, rinderpest, anthrax, glanders, hog cholera, chicken cholera, lumpy jaw and other diseases of animals, some of which also attack man. If the suffering dumb creatures could but speak, they too would pray that this good work should still continue unhindered.

THE ACHIEVEMENTS OF THE FOES OF RESEARCH.

Not a single human life has been saved by their efforts.

Not a single beneficent discovery has been made by them.

Not a single disease has been abated or abolished by them.

All that they have done is to resist progress—to spend $500,000 in 30 years in Great Britain alone, and very large amounts of money in the United States—and to conduct a campaign of abuse and gross misrepresentation.

They apparently care little or nothing for the continued suffering and death of human beings, the grief and not seldom the ensuing poverty of their families, provided that 26 out of every 1,000 dogs and cats, monkeys and guinea-pigs, mice and frogs experimented on shall escape some physical suffering.

They insist, therefore, that all experimental research on animals shall stop and—astounding cruelty—that thousands of human beings shall continue year after year to suffer and to die.

The Age of Experiment is the Age of Progress. This is true in mechanics, in engineering, in electricity, in every department of human knowledge in which experimental investigation is possible.

Medicine is no exception. Stop experiment and you stop progress. But while stopping progress in other departments only means that we shall have no further development in the external comforts and conveniences of life, the arrest of the experimental method in medicine means that progress in the knowledge of the cause and cure of disease shall stop and that our present sufferings and sorrowful bereavements from the onslaught of cancer, scarlet fever, measles, whooping-cough and all the other foes of health and life—especially of our dear children—must continue.

In the last 50 years, we have made more progress than in the preceding 50 centuries. I believe that if experimental research is continued and aided, the next 50 years will be still more prolific of benefit to mankind than even the past 50 years.

I have absolute confidence in the humanity, the intelligence and the common sense of this nation that they will see to it that this progress shall *not* be halted by the outcries and misstatements of the antivivisectionists.

Dr. S. Weir Mitchell, when visiting the Antivivisection Exhibition in Philadelphia, put the matter in a nutshell when he said to one of the guides, "Your exhibition is not quite complete. You should place here a dead baby and there a dead guinea-pig with the motto, 'Choose between them.'"[31]

[29] Mrs. White in her letter (p. 144) argues that this statement is incorrect because, forsooth, yellow fever "is still flourishing in a number of places in South America, Central America and Mexico." Of course, it is, but all the world knows that if they adopted the methods of Colonel Gorgas in the Canal Zone, yellow fever would soon be banished from those other places. Since May 17th, 1906 (now, October, 1912, almost six and a half years ago), not a single case of yellow fever has originated on the isthmus!

[30] See SCIENTIFIC AMERICAN, December 27th, 1913, p. 486.

Our European Population

IN the *Journal* of the Washington Academy of Sciences for January 4th, 1914, occurs a brief *résumé* of an interesting talk by Dr. Daniel Folkmar before the Anthropological Society of Washington on "Some Results of the First Census of European Races in the United States." If the total white population of the United States in 1910, about 82 millions, be taken as 100 per cent, the native stock constitutes 60.5 per cent. The "foreign stock" made up thus 39.5 per cent of our white population in 1910. Of this, 27.1 per cent came from northwestern Europe, i. e., English, Germans, Scandinavians and North French, while less than 13 per cent came from southern and eastern Europe, mostly Poles, Yiddish Hebrews, Italians, Greeks and Bulgarians. The five linguistic races contributing most are, in order, English, German, Italian, Polish, Yiddish; the English furnishing about 10 millions, the German 7 millions and none of the others equaling one quarter of the German.—*Science Conspectus.*

[31] Of course, not all antivivisectionists are to be grouped with those who are responsible for the letters, the epithets and the persistent misstatements mentioned in this paper. I have, for example, some most esteemed personal friends who are more or less opposed to research by means of experiments on animals. But I believe that most of the reasonable persons who take this stand are not well informed, either as to the character of such researches, to their profound importance to the human race and to animals, or to their wonderfully beneficent results. They are misled by the misstatements of the chief antivivisectionists, and their kindly hearts are so shocked by the asserted "torture" of dogs, cats, etc., that they lose sight of the real and horrible torture inflicted on human beings by diseases which the advocates of research are endeavoring to banish. Had they ever stood as in the past, I have stood, knife in hand, by the bedside of a gasping livid child struggling for breath, ready to do a tracheotomy when the surely tightening grip of diphtheria made it necessary to interfere, they would hail with delight the blessed antitoxin which has abolished the knife and enormously diminished the mortality of that curse of childhood. They would surely bless God that such a discovery as this antitoxin could be made *solely by experiments on animals.* The sufferings of a few such animals is as nothing compared with the lessening of suffering and saving of life for multitudes of human beings (to say nothing of the saving of sorrow and suffering to their families and friends), not only now, but for all time to come.

Uses of Tantalum.

IN the *Chemiker Zeitung* some uses of tantalum are pointed out. Below 200 deg. Cent. the metal is not attacked by air or oxygen, nor by acids, except concentrated hydrofluoric acid. It is not attacked by aqua regia, nor by aqueous solutions of alkalies, but is attacked by fused alkalies. It is a good substitute for platinum electrodes when used as cathodes. If used as an anode it rapidly oxidizes, which necessitates a thin electrolytic coat of platinum. It has a peculiar advantage for the electrolytic analysis of metals, as the deposit can be removed by solution in acids.

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